

Final Report

**2010 FUTURE YEAR OZONE MODELING
FOR THE DALLAS/FORT WORTH AREA**

Work Order No. 582-04-65563-04

Prepared for

Texas Commission on Environmental Quality
12118 Park 35 Circle
Austin, Texas 78753

Prepared by

Gerard Mansell
Greg Yarwood
Steven Lau
James Russell
Edward Tai

ENVIRON International Corporation
101 Rowland Way, Suite 220
Novato, CA 94945

August 31, 2004

TABLE OF CONTENTS

	Page
1.0 INTRODUCTION.....	1-1
2.0 EMISSIONS PROCESSING	2-1
Data Sources for 1999.....	2-1
Data Sources for 2010.....	2-2
Emission Summaries for 2010	2-5
3.0 OZONE MODELING	3-1
CAMx Model Configuration and Inputs.....	3-1
Updated 1999 Base Case	3-3
Ozone Modeling Results for 1999 and 2010	3-3
Projected 2010 8-Hour Ozone Design Values	3-20
Emission Sensitivity Simulations For 2010.....	3-25
4.0 SUMMARY AND CONCLUSIONS	4-1
5.0 REFERENCES.....	5-1

TABLES

Table 2-1	Summary of emissions data sources for 1999.....	2-1
Table 2-2.	2010 NO _x emissions by source category for the DFW area counties.....	2-7
Table 2-3.	2010 VOC emissions by source category for the DFW area counties.....	2-8
Table 2-4.	2010 CO emissions by source category for the DFW area counties.....	2-9
Table 2-5.	2010 total gridded Texas emissions for each episode day by source.....	2-
Table 2-6.	2010 total gridded emissions for state other than Texas.....	2-
Table 2-7.	Summary of 2010 model ready emissions for Tuesday August 17 th by source region and category.....	2-12
Table 2-8.	Summary of 1999 model ready emissions for Tuesday August 17 th by source region and category.....	2-13
Table 2-9.	Ratio of 2007 to 1999 model ready emissions for Tuesday August 17 th by source region and category.....	2-14
Table 2-10.	Emissions source area definitions.....	2-14

Table 3-1.	DFW 8-Hour O ₃ Design Values.....	3-22
Table 3-2.	2010 8-hour ozone design value scaling analysis for monitors in the DFW area. The scaled 2010 design values are in the right hand column of the lower panel.....	3-24
Table 3-3.	Emission reduction matrix for ‘Directional Guidance’ sensitivity simulations	3-25
Table 3-4.	Source-specific emission reductions percentages based on 40 tpd reduction across the DFW 9-County region.	3-26

FIGURES

Figure 1-1.	CAMx modeling domain for the August 1999 episode showing the 36-km regional grid and the nested 12-km and 4-km fine grids.....	1-2
Figure 2-1.	Emissions source areas used to prepare the emission summary tables by geographic area. The areas are described in Table 2-8.....	2-11
Figure 2-2.	2010 NO _x emissions for Tuesday August 17 th on the 4-km grid.	2-15
Figure 2-3.	2010 VOC emissions for Tuesday August 17 th on the 4-km grid.....	2-16
Figure 2-4.	2010 CO emissions for Tuesday August 17 th on the 4-km grid.....	2-17
Figure 2-5.	2010 NO _x emissions for Tuesday August 17 th on the 12-km emissions grid	2-18
Figure 2-6.	2010 VOC emissions for Tuesday August 17 th on the 12-km emissions grid.	2-19
Figure 2-7.	2010 CO emissions for Tuesday August 17 th on the 12-km emissions grid.	2-20
Figure 3-1.	Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).	3-4
Figure 3-2.	Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).....	3-8
Figure 3-3.	Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).....	3-12
Figure 3-4.	Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).....	3-16
Figure 3-5.	Overview of the 8-hour ozone attainment test methodology.....	3-21
Figure 3-6.	DFW ozone monitors and maximum design value periods.....	3-23
Figure 3-7.	Eight-hour ozone response curves for NO _x emission reduction scenarios.....	3-31
Figure 3-8.	Eight-hour ozone response curves for VOC emission reduction scenarios.....	3-32
Figure 3-9.	Eight-hour ozone response curves for NO _x /VOC emission reduction scenarios.....	3-32

1.0 INTRODUCTION

This report describes the results of the 2010 future year ozone modeling of the Dallas/Fort Worth (DFW) area using an August 1999 episode. The development of the August 13-22, 1999 episode by ENVIRON for the Texas Commission on Environmental Quality (TCEQ) was described previously by Mansell et al., (2003) and Emery et al., (2004). The 2010 future year ozone results for 2010 described here will be used by the TCEQ in planning activities for the 8-hour ozone standard.

Background

The 1990 Clean Air Act Amendments authorized the Environmental Protection Agency (EPA) to designate areas failing to meet the National Ambient Air Quality Standard (NAAQS) for ozone as nonattainment and to classify them according to severity. Once an area is declared nonattainment, the state must develop a State Implementation Plan (SIP) to improve the air quality by the attainment deadline. The SIP must contain an attainment demonstration, usually based upon photochemical modeling to show attainment by the deadline.

In 1997, the EPA established a new ozone standard, set at 0.08 parts per million ozone averaged over an 8-hour time frame. New implementation guidance for the 8-hour standard was issued on April 15, 2004. The new guidance classifies nine counties in the DFW area (Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker and Rockwall) as moderate 8-hour nonattainment. A State Implementation Plan (SIP) for DFW must be developed and submitted to EPA by June 2005, and must demonstrate attainment of the 8-hour standard not later than June 2010.

Basis for the 2010 Modeling

Attainment demonstration modeling for 8-hour ozone uses a “design value scaling” (DV scaling) method described by EPA in the draft 8-hour ozone modeling guidance (EPA, 1999). Briefly, this approach estimates future year ozone DVs by scaling the historical base year DVs by relative reduction factors (RRFs) determined from photochemical modeling. The important implication is that 8-hour attainment demonstrations use ozone-modeling results in a relative sense rather than relying upon the absolute ozone levels modeled in the future year. Therefore, consistency between the base and future year modeling methods is particularly important to 8-hour ozone modeling.

The 2010 future year ozone modeling described here used the latest version 4.03 of the CAMx model with revised meteorological data and the most recently available emission inventory projections from the TCEQ. The original 1999 base case modeling (run 7c) described by Mansell et al. (2003) used CAMx version 4.02 and different meteorology data. Emery et al., (2004) updated the meteorological data for the August 1999 episode and reevaluated the CAMx model performance. The 2010 modeling results presented here should be compared to the 1999 base case (run 17b) developed by Emery et al. (2004).

The modeling domain for this study, shown in Figure 1-1, provides a 4-km high-resolution grid in the DFW area nested within 12-km and 36-km grids covering much of the South, Southeast and Central US. This modeling domain was designed to provide high-resolution for all sources in the DFW area and also include all regional sources within a 2-3 day transport time of DFW.

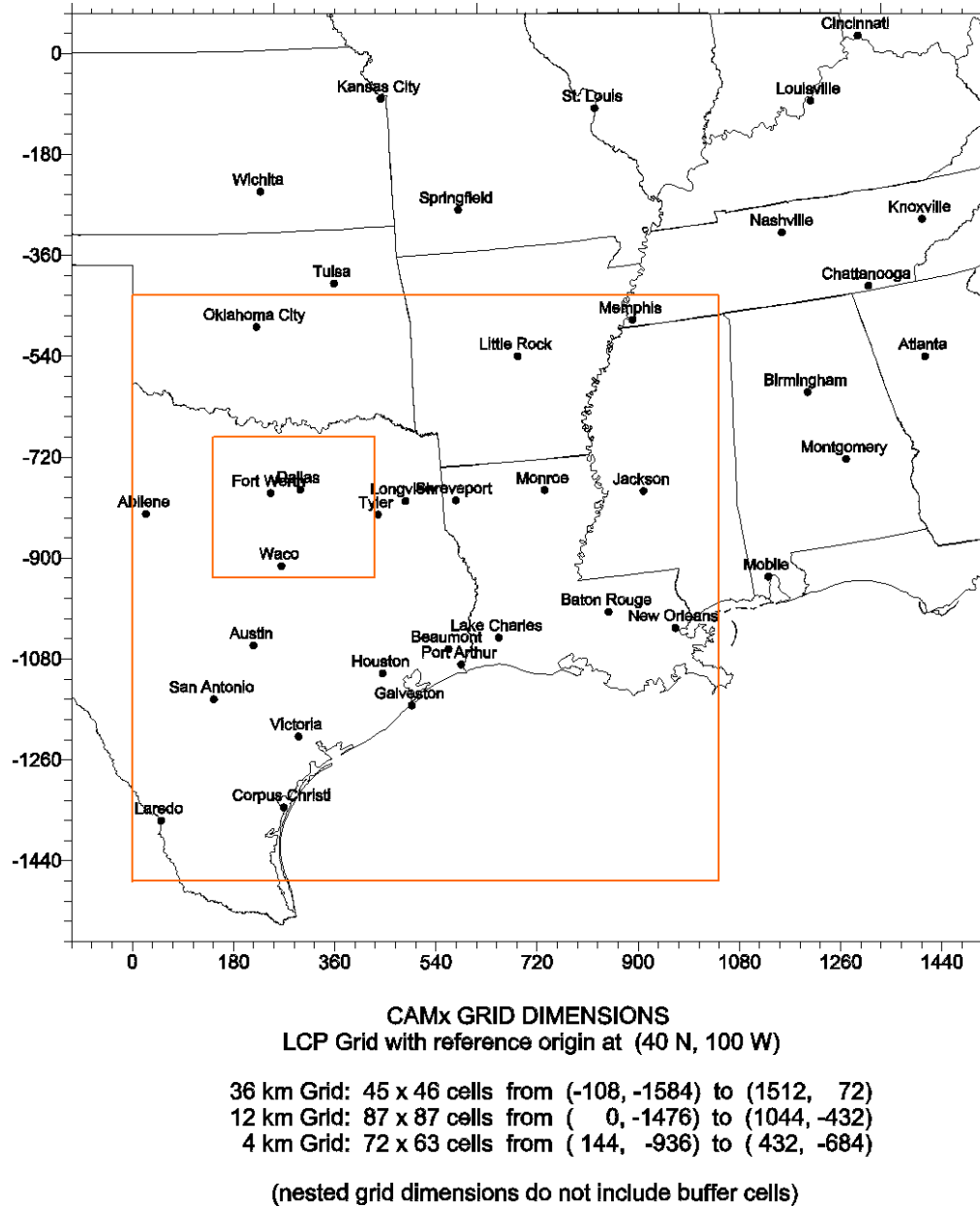


Figure 1-1. CAMx modeling domain for the August 1999 episode showing the 36-km regional grid and the nested 12-km and 4-km fine grids.

2.0 EMISSIONS PROCESSING

The August 13-22, 1999 episode, a Friday through Sunday, is being modeled in CAMx using a Lambert Conformal Projection (LCP) nested grid configuration with grid resolutions of 36, 12 and 4-km (Figure 1-1). In CAMx, emissions are separated between surface (surface and low level point) emissions and elevated point source emissions. For the surface emissions, a separate emission inventory is required for each grid nest, i.e., three inventories. For elevated point sources, a single emission inventory is prepared covering all grid nests.

Two emissions modeling domains are used to generate the required CAMx ready inventories:

1. **Dallas/Fort Worth Non-Attainment Area 4-km Grid.** The DFW emissions grid has 72 x 63 cells at 4-km resolution and covers the same area as the CAMx 4-km nested grid shown in Figure 1-1.
2. **Regional Emissions Grid.** Emissions for the CAMx 36-km and 12-km grids are prepared together in a single emissions processing step for efficiency. The regional emissions grid has 135 x 138 cells at 12-km resolution and covers the full area shown in Figure 1-1. This emissions grid is used for the 12-km CAMx grid by “windowing out” emissions for the appropriate region. In addition the regional emissions grid is aggregated from nine 12-km cells to one 36-km cell over the entire area to generate the CAMx 36-km grid.

DATA SOURCES FOR 1999

The development of emission inventories for the 1999 base year is documented in Mansell et al., 2003. In august of 2004, the 1999 emission inventory was updated to reflect the most recent enhancements to the on-road mobile source category. The TCEQ provided gridded on-road mobile source data files for the entire domain. The updates for the on-mobile source emissions for 1999 are described in Emery et al., 2004. Table 2-1 provides a summary of data sources used in the development of the 1999 inventory. Emission summaries for 1999 by source category and county were presented in Mansell et al., 2003.

Table 2-1. Summary of emissions data sources for 1999.

Category	Region	Data Source
Mobile	DFW	TCEQ link-based, MOBILE6
	Texas major urban	TTI link-based, MOBILE6 via TCEQ
	Other Texas	TTI county level, MOBILE6 via TCEQ
	Outside Texas	EPA NEI99 Version 3, MOBILE6
Offroad	Texas	NONROAD 2002 model
	DFW	NCTCOG local data and NONROAD 2002 model
	Outside Texas	EPA NEI99 Version 2
Area	Texas	TCEQ
	Outside Texas	EPA NEI99 Version 2
Point	TX and LA EGU	EPA acid rain hourly data processed by TCEQ
	Texas other	1999 PSDB
	Louisiana other	LA DEQ provided to TCEQ
	OK EGU	EPA acid rain hourly data processed by ENVIRON
	OK other	EPA NEI99 Version 2 with ODEQ corrections
	Other	EPA NEI99 Version 2
Offshore	Texas	TCEQ offshore and shipping emissions
Biogenic	DFW	GloBEIS3.1 with TCEQ LULC data
	Outside DFW	GloBEIS2.2 with TCEQ and BELD3 LULC data

DATA SOURCES FOR 2010

The future year 2010 emission inventory was developed jointly by ENVIRON and TCEQ. The TCEQ developed gridded, model-ready emissions files for area and off-road mobile sources for the entire state of Texas for both the 12-km regional and 4-km DFW emissions grids. On-road mobile source emissions for all areas were based on EPA's MOBILE6 model. Off-road mobile source emissions were based on the 2002 version of EPA's NONROAD model for most source categories. Point source emissions were based on data from TCEQ's point source database (PSDB) and EPA's National Emissions Inventory. Area source emissions for Texas were based on TCEQ data and other states were based on EPA's data developed for a rulemaking on heavy-duty diesel (HDD) engines. Biogenic emissions were unchanged from the 1999 base case inventory as described by Mansell, et al. (2003).

The data sources for the 2010 emissions inventories are described in more detail below followed by summary tables of gridded emissions by county and source category. Spatial plots of the 2010 NO_x, VOC and CO emissions by source category for the August 17 episode day are presented for the 12-km and 4-km grids.

On-Road Mobile Sources

All on-road mobile source emissions were based on EPA's MOBILE6 model. Control measures for on-road mobile sources were modeled using MOBILE6. On-road mobile source emissions were developed by TCEQ using MOBILE6.2. The modeling files were downloaded from TCEQ's FTP server:

<ftp://ftp.tnrc.state.tx.us/pub/OEPAA/TAD/Modeling/DFWAQSE/Modeling/EI/Mobile/2010/eps2x>

The following files were provided:

- gridded.m62.2010.df_2km.tar
- gridded.m62.2010.df_4km.tar
- gridded.m62.2010.df_12km.tar
- gridded.m62.2010.hg_12km.tar
- gridded.m62.2010.bp_12km.tar
- gridded.m62.2010.tx_12km.tar
- gridded.m62.2010.us_12km.tar

DFW: On-road mobile source link-based emissions were developed by TCEQ using MOBILE6.2. The DFW on-road mobile emissions are based on a 5-day work-week using 2010 vehicle miles traveled (VMT) and fleet turnover with day-specific adjustments for temperature and humidity.

Rest of Texas: County-level emissions from MOBILE6 for 4 day of week scenarios and 2010 VMT and fleet turnover developed by TTI with day-specific adjustments for temperature and humidity.

Other States: MOBILE6.2 county level emissions for typical summer day conditions (as used in the NEI999v2) with EPA data for 2007 VMT and fleet turnover.

Off-Road Mobile Sources

Off-road mobile source emissions for all categories except aircraft, commercial marine and locomotives were from EPA's 2002 version of the NONROAD model (NONROADv2002). The TCEQ developed the NONROAD model input data for Texas and EPA's data were used elsewhere. Emissions for aircraft, commercial marine and locomotives are not included in NONROAD and so were estimated by TCEQ and EPA for 1999 and projected to other years using EPA data including the Economic Growth Analysis System (EGAS).

Texas: TCEQ provided gridded model-ready off-road mobile source emissions data. The modeling files were downloaded from TCEQ's anonymous FTP server:

- ftp://ftp.tnrrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/dfw_04km_areaNR
- ftp://ftp.tnrrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/reg_12km_areaNR

Other States: NONROADv2002 with default input data for 2010. Aircraft, commercial marine and railroad emissions for 2010 developed by EPA for a rulemaking on "heavy duty diesel" emissions.

Area Sources

Emissions for stationary sources that are not individually inventoried (area sources) were based on data developed for 2002 by TCEQ and EPA. Emissions for years later than 2002 were projected using EGAS and other data.

Texas: TCEQ provided gridded model-ready area source emissions data. The modeling files were downloaded from TCEQ's FTP server:

- ftp://ftp.tnrrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/dfw_04km_areaNR
- ftp://ftp.tnrrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/reg_12km_areaNR

Other States: EPA 2007 emission inventory developed for a rulemaking on "heavy duty diesel" emissions.

Point Sources

Emissions for stationary sources that are inventoried individually (point sources) were based on data from TCEQ, EPA and the Louisiana DEQ (LDEQ). The TCEQ provided model-ready point source emissions data for the entire modeling domain. Gridded low-level point source emission files were provided for both the 12-km regional and 4-km DFW modeling domains. The data were downloaded from TCEQ's FTP server:

ftp://ftp.tnrrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/forENVIRON/dfw_2010/point

The following files were provided:

- dfw_2010_pts.tar.gz

Biogenic Emissions

Biogenic emissions were prepared using both versions 2.2 and 3.1 of the GloBEIS model (Yarwood et al., 1999 a,b). The GloBEIS model was developed by the National Center for Atmospheric Research and ENVIRON under sponsorship from the TCEQ.

GloBEIS Version 2.2

GloBEIS version 2.2 was based on the EPA BEIS2 model algorithms with the following improvements:

- Updated emission factor algorithm (called the BEIS99 algorithm).
- Compatible with the EPA's Biogenic Emission Landcover Database – Version 3 (BELD-3).
- Compatible with the TCEQ's Texas specific landcover database which includes local surveys of DFW vegetation (Yarwood et al., 1999b).
- Ability to directly input solar radiation data for photosynthetically active radiation (PAR).

GloBEIS 2.2 requires input data for landuse/landcover (LULC), temperature and solar radiation. The TCEQ provided these data for the August 1999 episode period (Yarwood et al., 2001). Briefly, these data were:

- TCEQ LULC data for Texas and Mexico.
- EPA BELD-3 LULC data for all other U.S. States.
- Hourly temperature data from interpolated NWS observations.
- Hourly solar radiation (PAR) based on GOES satellite data as analyzed by the University of Maryland.

GloBEIS Version 3.1

GloBEIS, version 3.1, was released in 2002 (Guenther et al., 2002) and has the following changes from version 2.2:

- Options to model the impacts of drought and prolonged periods of high temperature.
- Optional leaf energy balance model.
- Optional direct input of leaf area index (e.g., from satellite data).
- Option to model effects of leaf age on emissions (seasonal effects).
- Chemical speciation for the SAPRC99 and CB4 mechanisms.
- Updated speciation of other VOC emissions.
- GloBEIS3 emission factor model (previously called BEIS99).

GloBEIS3.1 and GloBEIS2.2 codes calculate the same emissions when using the same input data. Using the options to model drought impacts and prolonged periods of high temperature requires input data for humidity and wind speed in addition to temperature. It is important for these humidity and temperature inputs to be consistent (e.g., from a meteorological model such as MM5).

Biogenic Inventory Preparation

GloBEIS was used to calculate day specific, gridded, speciated, hourly emissions of biogenic VOCs and NO_x for each modeling grid (36-km, 12-km, 4-km). The model versions and input data were as follows.

DFW 4-km grid area: Biogenic emissions were calculated using GloBEIS3.1 with TCEQ LULC data, MM5 temperature data and GOES satellite PAR data.

Texas outside of the DFW 4-km grid area: Biogenic emissions were calculated using GloBEIS2.2 with TCEQ LULC data, interpolated observed temperature data and GOES satellite PAR data.

States outside of Texas: Biogenic emissions were calculated using GloBEIS2.2 with BELD-3 LULC data, interpolated observed temperature data and GOES satellite PAR data.

Mexico: Biogenic emissions were calculated using GloBEIS2.2 with TCEQ LULC data, interpolated observed temperature data and GOES satellite PAR data.

EMISSION SUMMARIES FOR 2010

The emission inventories for 2010 are summarized in Tables 2-2 through 2-8. These tables are:

- Tables 2-2 to 2-4 present episode day emission summaries by major source type for the DFW area counties.
- Table 2-5 presents total gridded Texas emissions for each episode day.
- Table 2-6 summarizes the gridded emissions by major source type for states other than Texas.
- Table 2-7 shows the 2007 NO_x and VOC emissions for the entire modeling domain broken out by several geographic areas.

Tables 2-7 through 2-9 show the emission inventories for the entire modeling domain in a concise format for just the August 17th day (Tuesday). The geographic areas used in Table 2-7 are the same as used in previous ozone source apportionment modeling (Mansell et al., 2003) as defined in Figure 2-1. The source categories in Tables 2-7 through 2-9 are biogenic, on-road mobile, stationary point sources (elevated plus low-level) and other anthropogenic sources. The other anthropogenic category combines area and off-road mobile sources. Table 2-10 provides the definition of the source regions corresponding to the numbered regions in Figure 2-1.

Table 2-7 is prepared directly from model ready emissions files and this introduces some uncertainty into the emissions totals because: (1) County boundaries are approximated to the nearest grid-cell boundary, and; (2) The emissions processing provides CAMx with moles of emissions rather than tons of emissions. Therefore, in the case of minor differences between Tables 2-2 through 2-6 and Table 2-7, the former should be considered more accurate.

Table 2-8 shows the same information as Table 2-7 but for the 1999 base year rather than 2010 future year emission inventory. Comparing Tables 2-7 and 2-8 shows the trends in emissions from the base to future year resulting from the combined effects of activity growth and emission

control strategies. Table 2-9 shows the ratio of the 2010 to 1999 emissions shown in Tables 2-7 and 2-8. In a few cases the ratios are large numbers because the 1999 emissions were very low, so care is needed in interpreting the ratios shown in Table 2-9. The following points are noted from the emissions trend analysis shown in Table 2-9:

- There are significant reductions in on-road mobile source NO_x and VOC emissions in all regions from 1999 to 2010 resulting from cleaner vehicles and fuels.
- The on-road mobile source NO_x emission reductions are influenced by new standards for heavy-duty diesel vehicles and therefore the overall on-road mobile source NO_x reduction tends to be larger in areas with a high contribution from truck traffic.
- There are significant reductions in elevated point source NO_x emissions in most regions from 1999 to 2010.
- The 2010 point source NO_x in the 4 core counties is substantially reduced, but increases in the surrounding 12 counties.
- Point source NO_x emissions are substantially in 2010 for the “Other States” region (region 25 in Figure 2-1) due to EPA’s NO_x SIP call.
- Reductions in “other anthropogenic” NO_x emissions tend to be less than for on-road mobile or point sources. Other anthropogenic combines off-road mobile and area sources.

The spatial distribution of the emissions is shown by source category in Figures 2-2 through 2-7. The 4-km grid model ready emissions for Tuesday August 17th are shown in Figures 2-2 through 2-4 for NO_x, VOC and CO, respectively. Figures 2-5 through 2-7 show the corresponding information for the 12-km CAMx grid.

Table 2-2. 2010 NOx emissions by source category for the DFW area counties.

Date	Type1	48085	48113	48121	48139	48213	48221	48231	48251	48257	48367	48397	48439
13-Aug	Area	2.2	19.4	10.9	0.3	3.9	0.3	0.3	0.3	0.2	1.2	0.1	11.4
	mobile	13.6	63.1	13.4	8.3	2.4	1.2	4.7	4.8	6.2	5.5	2.7	39.5
	offroad	13.9	49.9	7.4	8.8	3.5	0.6	2.4	6.4	3.2	3.6	1.0	40.6
	Pts	3.3	16.8	2.8	4.3	6.5	18.6	0.3	4.4	0.8	2.2		11.9
14-Aug	Area	1.7	14.1	10.5	0.2	3.9	0.3	0.2	0.2	0.1	1.2	0.1	8.7
	mobile	9.2	41.2	9.0	5.1	1.9	0.9	3.4	3.3	4.1	3.6	1.5	27.0
	offroad	9.8	37.9	5.7	6.4	3.6	0.5	2.1	6.1	2.9	3.4	0.7	33.1
	Pts	2.3	16.3	2.5	4.3	7.1	17.0	0.3	4.3	0.8	2.3	0.0	11.4
15-Aug	Area	1.1	8.8	10.1	0.2	3.8	0.2	0.2	0.1	0.1	1.1	0.1	5.9
	mobile	7.0	31.6	6.7	4.9	2.0	0.9	3.4	3.3	4.0	3.3	1.1	19.6
	offroad	7.7	30.5	4.6	5.3	3.5	0.4	1.9	5.8	2.7	3.3	0.5	28.5
	Pts	2.8	15.9	2.5	4.3	7.1	18.9	0.1	4.3	0.8	2.3	0.0	12.0
16-Aug	Area	2.2	19.4	10.9	0.3	3.9	0.3	0.3	0.3	0.2	1.2	0.1	11.4
	mobile	13.8	63.6	13.6	6.9	2.0	1.0	4.0	4.0	5.3	4.7	2.7	39.9
	offroad	13.9	49.9	7.4	8.8	3.5	0.6	2.4	6.4	3.2	3.6	1.0	40.6
	Pts	3.3	16.8	2.8	4.3	6.5	18.6	0.3	4.4	0.8	2.2	0.0	11.9
17-Aug	Area	2.2	19.4	10.9	0.3	3.9	0.3	0.3	0.3	0.2	1.2	0.1	11.4
	mobile	13.9	63.1	13.8	6.9	2.0	0.9	4.0	4.0	5.2	4.7	2.7	40.1
	offroad	13.9	49.9	7.4	8.8	3.5	0.6	2.4	6.4	3.2	3.6	1.0	40.6
	Pts	3.3	16.8	2.8	4.3	6.5	18.6	0.3	4.4	0.8	2.2	0.0	11.9
18-Aug	Area	2.2	19.4	10.9	0.3	3.9	0.3	0.3	0.3	0.2	1.2	0.1	11.4
	mobile	13.3	60.9	13.2	6.8	1.9	0.9	3.8	3.8	5.0	4.5	2.6	37.9
	offroad	13.9	49.9	7.4	8.8	3.5	0.6	2.4	6.4	3.2	3.6	1.0	40.6
	Pts	3.3	16.8	2.8	4.3	6.5	18.6	0.3	4.4	0.8	2.2	0.0	11.9
19-Aug	Area	2.2	19.4	10.9	0.3	3.9	0.3	0.3	0.3	0.2	1.2	0.1	11.4
	mobile	13.7	61.6	13.1	6.8	1.9	0.9	3.9	3.8	5.0	4.5	2.6	37.9
	offroad	13.9	49.9	7.4	8.8	3.5	0.6	2.4	6.4	3.2	3.6	1.0	40.6
	Pts	3.3	16.8	2.8	4.3	6.5	18.6	0.3	4.4	0.8	2.2	0.0	11.9
20-Aug	Area	2.2	19.4	10.9	0.3	3.9	0.3	0.3	0.3	0.2	1.2	0.1	11.4
	mobile	15.8	69.9	15.4	8.9	2.7	1.3	5.5	5.5	7.0	6.4	3.1	45.5
	offroad	13.9	49.9	7.4	8.8	3.5	0.6	2.4	6.4	3.2	3.6	1.0	40.6
	Pts	3.3	16.8	2.8	4.3	6.5	18.6	0.3	4.4	0.8	2.2	0.0	11.9
21-Aug	Area	1.7	14.1	10.5	0.2	3.9	0.3	0.2	0.2	0.1	1.2	0.1	8.7
	mobile	9.5	42.8	9.1	5.3	2.0	0.9	3.5	3.5	4.2	3.7	1.5	26.9
	offroad	9.8	37.9	5.7	6.4	3.6	0.5	2.1	6.1	2.9	3.4	0.7	33.1

Date	Type1	48085	48113	48121	48139	48213	48221	48231	48251	48257	48367	48397	48439
	Pts	2.3	16.3	2.5	4.3	7.1	17.0	0.3	4.3	0.8	2.3	0.0	11.4
22-Aug	Area	1.1	8.8	10.1	0.2	3.8	0.2	0.2	0.1	0.1	1.1	0.1	5.9
	mobile	6.7	31.4	6.6	4.8	1.9	0.9	3.2	3.3	3.8	3.3	1.0	19.4
	offroad	7.7	30.5	4.6	5.3	3.5	0.4	1.9	5.8	2.7	3.3	0.5	28.5
	Pts	2.8	15.9	2.5	4.3	7.1	18.9	0.1	4.3	0.8	2.3	0.0	12.0
Grand Total		283.6	1292.2	312.4	186.4	162.1	200.8	66.2	147.6	90.2	114.1	30.5	916.3

Table 2-3. 2010 VOC emissions by source category for the DFW area counties.

Date	Type1	48085	48113	48121	48139	48213	48221	48231	48251	48257	48367	48397	48439
13-Aug	Area	14.9	84.9	19.8	12.4	10.8	4.4	13.3	13.0	13.8	11.8	3.3	65.6
	mobile	9.4	42.0	8.7	2.9	2.2	0.9	2.8	2.7	3.1	2.4	1.0	25.6
	offroad	4.4	24.5	4.2	1.9	1.9	0.3	1.9	0.8	0.8	0.9	0.5	15.5
	Pts	1.3	12.8	1.9	3.4	0.7	0.4	0.1	0.4	0.4	0.9		9.1
14-Aug	Area	10.4	48.0	12.6	8.8	8.6	3.6	8.0	9.0	7.2	9.6	2.4	32.8
	mobile	6.6	29.5	6.2	2.5	1.9	0.8	2.5	2.4	2.7	2.1	0.7	18.1
	offroad	6.1	30.3	8.5	2.9	5.7	1.0	4.6	1.0	1.6	1.5	1.3	20.6
	Pts	0.6	9.7	1.1	3.3	0.7	0.4	0.1	0.4	0.4	0.9	0.0	6.5
15-Aug	Area	7.2	32.7	9.9	5.9	6.9	2.8	4.9	6.2	4.7	7.5	1.7	22.6
	mobile	5.3	23.5	4.9	2.6	1.9	0.9	2.5	2.4	2.7	2.1	0.5	14.4
	offroad	5.5	27.8	8.1	2.7	5.6	0.9	4.5	0.9	1.5	1.5	1.2	18.9
	Pts	0.6	9.7	1.1	3.3	0.7	0.4	0.1	0.4	0.4	0.9	0.0	6.5
16-Aug	Area	14.9	84.9	19.8	12.4	10.8	4.4	13.3	13.0	13.8	11.8	3.3	65.6
	mobile	8.5	37.6	7.9	2.2	1.6	0.7	2.1	2.1	2.3	1.8	0.9	23.2
	offroad	4.4	24.5	4.2	1.9	1.9	0.3	1.9	0.8	0.8	0.9	0.5	15.5
	Pts	1.3	12.8	1.9	3.4	0.7	0.4	0.1	0.4	0.4	0.9	0.0	9.1
17-Aug	Area	14.9	84.9	19.8	12.4	10.8	4.4	13.3	13.0	13.8	11.8	3.3	65.6
	mobile	8.8	38.6	8.2	2.2	1.6	0.7	2.2	2.1	2.3	1.8	0.9	23.6
	offroad	4.4	24.5	4.2	1.9	1.9	0.3	1.9	0.8	0.8	0.9	0.5	15.5
	Pts	1.3	12.8	1.9	3.4	0.7	0.4	0.1	0.4	0.4	0.9	0.0	9.1
18-Aug	Area	14.9	84.9	19.8	12.4	10.8	4.4	13.3	13.0	13.8	11.8	3.3	65.6
	mobile	8.8	38.9	8.2	2.2	1.6	0.7	2.2	2.1	2.3	1.8	0.9	23.7
	offroad	4.4	24.5	4.2	1.9	1.9	0.3	1.9	0.8	0.8	0.9	0.5	15.5
	Pts	1.3	12.8	1.9	3.4	0.7	0.4	0.1	0.4	0.4	0.9	0.0	9.1
19-Aug	Area	14.9	84.9	19.8	12.4	10.8	4.4	13.3	13.0	13.8	11.8	3.3	65.6
	mobile	9.0	39.0	8.3	2.3	1.7	0.7	2.2	2.1	2.4	1.8	0.9	23.8
	offroad	4.4	24.5	4.2	1.9	1.9	0.3	1.9	0.8	0.8	0.9	0.5	15.5

Date	Type1	48085	48113	48121	48139	48213	48221	48231	48251	48257	48367	48397	48439
	Pts	1.3	12.8	1.9	3.4	0.7	0.4	0.1	0.4	0.4	0.9	0.0	9.1
20-Aug	Area	14.9	84.9	19.8	12.4	10.8	4.4	13.3	13.0	13.8	11.8	3.3	65.6
	mobile	9.5	41.7	8.8	2.9	2.1	1.0	2.8	2.7	3.0	2.4	1.0	25.6
	offroad	4.4	24.5	4.2	1.9	1.9	0.3	1.9	0.8	0.8	0.9	0.5	15.5
	Pts	1.3	12.8	1.9	3.4	0.7	0.4	0.1	0.4	0.4	0.9	0.0	9.1
21-Aug	Area	10.4	48.0	12.6	8.8	8.6	3.6	8.0	9.0	7.2	9.6	2.4	32.8
	mobile	6.6	28.9	6.1	2.5	1.8	0.8	2.4	2.3	2.6	2.0	0.7	17.8
	offroad	6.1	30.3	8.5	2.9	5.7	1.0	4.6	1.0	1.6	1.5	1.3	20.6
	Pts	0.6	9.7	1.1	3.3	0.7	0.4	0.1	0.4	0.4	0.9	0.0	6.5
22-Aug	Area	7.2	32.7	9.9	5.9	6.9	2.8	4.9	6.2	4.7	7.5	1.7	22.6
	mobile	5.3	23.6	5.0	2.6	1.9	0.9	2.6	2.4	2.7	2.1	0.5	14.5
	offroad	5.5	27.8	8.1	2.7	5.6	0.9	4.5	0.9	1.5	1.5	1.2	18.9
	Pts	0.6	9.7	1.1	3.3	0.7	0.4	0.1	0.4	0.4	0.9	0.0	6.5
Grand Total		262.6	1393.2	309.9	185.2	154.7	57.0	159.9	144.2	147.3	145.7	44.1	966.9

Table 2-4. 2010 CO emissions by source category for the DFW area counties.

Date	Type1	48085	48113	48121	48139	48213	48221	48231	48251	48257	48367	48397	48439
13-Aug	Area	7.8	32.4	15.5	3.1	5.3	0.5	2.1	1.7	1.0	1.9	0.5	19.4
	mobile	151.6	652.8	142.8	45.0	26.9	12.8	38.6	36.4	42.4	32.7	16.3	407.0
	offroad	111.1	623.6	70.6	27.3	17.8	7.1	18.5	18.0	18.5	16.4	10.3	314.9
	Pts	2.2	15.4	1.6	4.6	4.7	5.3	0.1	1.3	0.1	1.5		13.7
14-Aug	Area	6.2	18.3	14.8	2.1	4.9	0.4	1.7	1.2	0.7	1.7	0.3	11.7
	mobile	111.3	491.4	106.7	40.9	23.7	11.2	34.6	32.4	37.5	29.0	12.1	304.1
	offroad	127.7	703.3	100.6	35.8	37.0	12.4	31.2	24.4	27.2	24.5	14.3	384.2
	Pts	2.1	15.2	1.6	4.5	4.9	5.3	0.1	1.3	0.1	1.5	0.0	12.7
15-Aug	Area	4.6	4.5	14.1	1.2	4.5	0.3	1.3	0.7	0.3	1.4	0.2	4.1
	mobile	89.5	392.7	86.3	42.7	24.6	11.9	36.1	33.7	38.8	30.8	9.7	248.3
	offroad	107.2	615.7	86.2	30.5	33.9	11.0	27.6	19.9	24.4	21.4	12.6	322.0
	Pts	2.1	15.7	1.6	4.5	4.9	5.3	0.1	1.3	0.1	1.5	0.0	13.6
16-Aug	Area	7.8	32.4	15.5	3.1	5.3	0.5	2.1	1.7	1.0	1.9	0.5	19.4
	mobile	131.6	560.8	123.5	32.5	19.7	9.3	28.1	26.2	30.7	23.6	14.1	354.1
	offroad	111.1	623.6	70.6	27.3	17.8	7.1	18.5	18.0	18.5	16.4	10.3	314.9
	Pts	2.2	15.4	1.6	4.6	4.7	5.3	0.1	1.3	0.1	1.5	0.0	13.7
17-Aug	Area	7.8	32.4	15.5	3.1	5.3	0.5	2.1	1.7	1.0	1.9	0.5	19.4
	mobile	136.3	578.1	128.0	33.2	20.3	9.5	28.9	26.8	31.7	24.0	14.5	362.8
	offroad	111.1	623.6	70.6	27.3	17.8	7.1	18.5	18.0	18.5	16.4	10.3	314.9

Date	Type1	48085	48113	48121	48139	48213	48221	48231	48251	48257	48367	48397	48439
	Pts	2.2	15.4	1.6	4.6	4.7	5.3	0.1	1.3	0.1	1.5	0.0	13.7
18-Aug	Area	7.8	32.4	15.5	3.1	5.3	0.5	2.1	1.7	1.0	1.9	0.5	19.4
	mobile	136.2	592.9	128.1	33.7	20.1	9.7	28.8	27.5	31.6	24.5	14.5	369.5
	offroad	111.1	623.6	70.6	27.3	17.8	7.1	18.5	18.0	18.5	16.4	10.3	314.9
	Pts	2.2	15.4	1.6	4.6	4.7	5.3	0.1	1.3	0.1	1.5	0.0	13.7
19-Aug	Area	7.8	32.4	15.5	3.1	5.3	0.5	2.1	1.7	1.0	1.9	0.5	19.4
	mobile	137.8	593.2	129.7	34.1	20.1	9.7	28.7	27.8	31.5	24.5	14.6	369.1
	offroad	111.1	623.6	70.6	27.3	17.8	7.1	18.5	18.0	18.5	16.4	10.3	314.9
	Pts	2.2	15.4	1.6	4.6	4.7	5.3	0.1	1.3	0.1	1.5	0.0	13.7
20-Aug	Area	7.8	32.4	15.5	3.1	5.3	0.5	2.1	1.7	1.0	1.9	0.5	19.4
	mobile	144.9	625.7	136.8	44.1	26.1	12.5	37.2	35.1	40.6	31.3	15.8	388.3
	offroad	111.1	623.6	70.6	27.3	17.8	7.1	18.5	18.0	18.5	16.4	10.3	314.9
	Pts	2.2	15.4	1.6	4.6	4.7	5.3	0.1	1.3	0.1	1.5	0.0	13.7
21-Aug	Area	6.2	18.3	14.8	2.1	4.9	0.4	1.7	1.2	0.7	1.7	0.3	11.7
	mobile	109.8	476.3	105.0	39.7	23.3	11.0	34.0	31.2	36.6	28.2	11.8	299.0
	offroad	127.7	703.3	100.6	35.8	37.0	12.4	31.2	24.4	27.2	24.5	14.3	384.2
	Pts	2.1	15.2	1.6	4.5	4.9	5.3	0.1	1.3	0.1	1.5	0.0	12.7
22-Aug	Area	4.6	4.5	14.1	1.2	4.5	0.3	1.3	0.7	0.3	1.4	0.2	4.1
	mobile	91.8	396.8	87.6	43.1	25.0	11.9	36.7	34.0	39.6	30.9	9.8	249.2
	offroad	107.2	615.7	86.2	30.5	33.9	11.0	27.6	19.9	24.4	21.4	12.6	322.0
	Pts	2.1	15.7	1.6	4.5	4.9	5.3	0.1	1.3	0.1	1.5	0.0	13.6
Grand Total		2466.5	12134.7	2138.7	756.1	576.5	256.4	579.9	534.7	584.2	501.8	252.4	6936.1

Table 2-5. 2010 total gridded Texas emissions for each episode day by source.**Table 2-6.** 2010 total gridded emissions for state other than Texas.

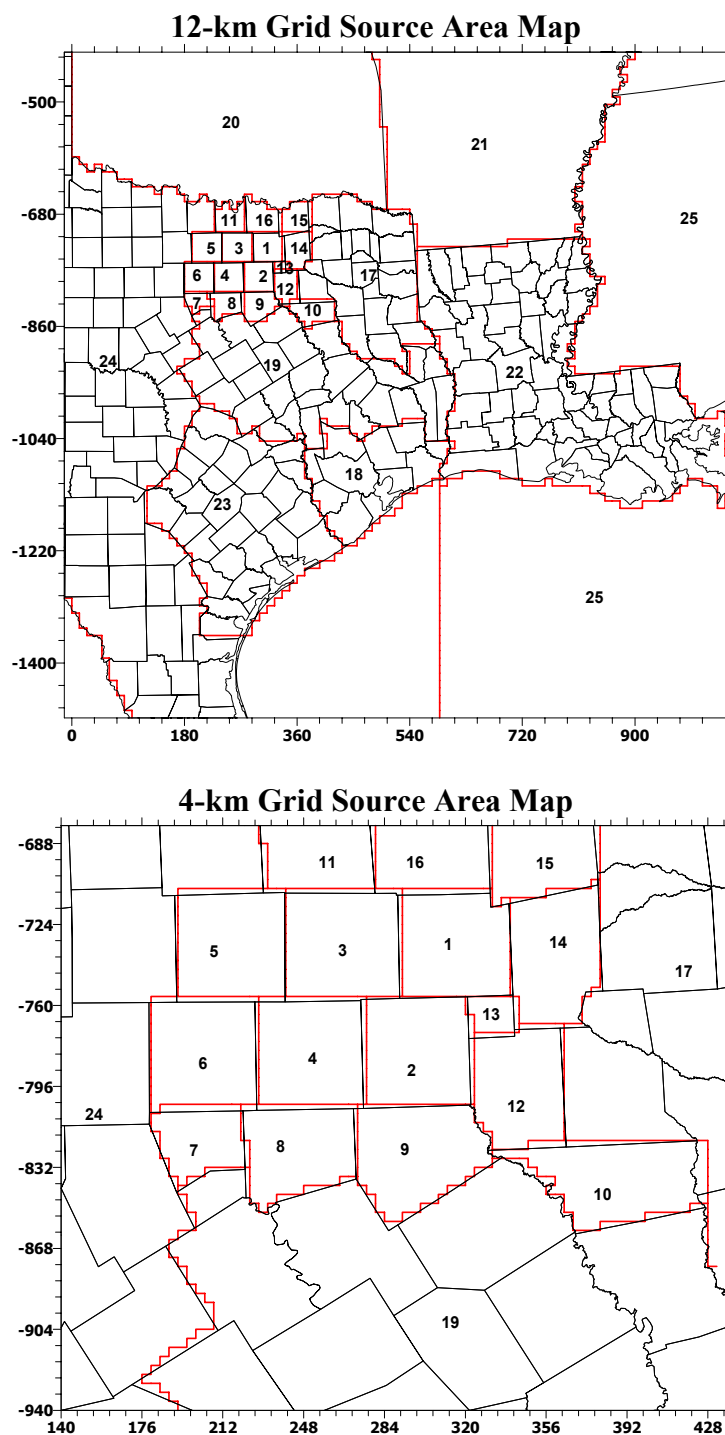


Figure 2-1. Emissions source areas used to prepare the emission summary tables by geographic area. The areas are described in Table 2-8.

Table 2-7. Summary of 2010 model ready emissions for Tuesday August 17th by source region and category.

2010 run01b	Bio		On Road		All Points		Other Anthropogenic *	
Source Region	NOX	VOC	NOX	VOC	NOX	VOC	NOX	VOC
Collin	11.2	29.0	11.9	7.2	3.0	1.2	14.9	19.0
Dallas	4.2	56.2	62.4	35.2	18.0	12.2	67.8	111.7
Denton	8.1	66.4	14.3	7.7	2.7	1.7	17.9	23.2
Tarrant	2.9	65.5	42.2	23.2	13.0	9.7	54.4	85.8
Core	26.4	217.2	130.9	73.3	36.7	24.8	155.0	239.7
Wise	2.3	149.5	3.4	1.6	10.7	2.0	18.0	18.4
Parker	0.6	130.9	5.0	1.9	4.1	1.0	5.1	13.0
Hood	0.2	34.5	0.9	0.7	20.3	0.6	0.9	5.1
Johnson	4.8	108.3	4.4	2.2	4.4	0.2	7.7	15.5
Ellis	14.3	89.7	6.8	2.1	44.5	6.9	9.0	15.0
Henderson	0.7	275.5	2.7	2.0	6.5	0.6	7.8	14.5
Cooke	3.7	95.4	2.8	0.9	0.0	0.0	2.9	11.2
Kaufman	5.0	105.8	4.9	2.1	6.8	2.0	3.2	14.1
Rockwall	1.6	3.6	2.3	0.8	0.0	0.0	1.0	3.7
Hunt	6.8	77.2	4.0	2.0	0.3	0.1	2.7	15.3
Fannin	7.1	137.0	1.3	0.7	0.0	0.0	1.3	6.3
Grayson	9.1	161.5	6.4	2.6	17.1	0.4	7.9	17.8
Perimeter 12	56.3	1369.0	45.0	19.5	114.7	13.9	67.4	149.9
Central Texas	113.5	6044.6	64.1	26.2	198.8	26.8	142.2	237.7
East Texas	16.2	4901.6	80.3	33.6	218.8	21.2	127.8	209.8
South Texas	228.6	2109.1	158.5	74.6	321.6	24.4	212.5	457.5
HGBPA	19.9	1772.3	139.6	74.0	296.3	106.9	174.6	279.7
West Texas	525.9	6203.2	131.2	56.5	228.2	19.8	397.2	661.0
AR	132.3	13782.8	117.2	59.6	385.6	124.0	312.2	363.8
LA	108.5	10085.1	180.6	96.2	1044.7	248.3	970.5	385.3
OK	225.6	7988.2	175.2	100.6	683.4	167.3	243.9	301.5
Other States	1975.7	66127.3	1784.4	980.8	6222.5	1785.1	3274.0	3822.6
Total	3428.9	120600.4	3007.0	1595.0	9751.1	2562.3	6077.4	7108.3

* Other anthropogenic emissions are area sources plus off-road mobile sources.

Table 2-8. Summary of 1999 model ready emissions for Tuesday August 17th by source region and category.

1999 run17b	Bio		On Road		All Points		Other Anthropogenic *	
Source Region	NOX	VOC	NOX	VOC	NOX	VOC	NOX	VOC
Collin	11.2	29.0	29.2	13.7	5.2	0.7	24.1	23.9
Dallas	4.2	56.2	177.9	76.0	60.7	11.7	82.9	118.0
Denton	8.1	66.4	36.5	15.0	5.2	2.7	18.7	20.0
Tarrant	2.9	65.5	117.5	47.6	40.1	12.5	64.4	82.4
Core	26.4	217.2	361.0	152.4	111.3	27.6	190.1	244.2
Wise	2.3	149.5	8.1	3.2	11.6	2.0	33.1	20.2
Parker	0.6	130.9	15.0	4.3	4.1	0.9	16.6	11.7
Hood	0.2	34.5	2.0	1.2	30.1	0.3	3.8	4.6
Johnson	4.8	108.3	11.4	4.7	6.0	0.5	9.2	11.1
Ellis	14.3	89.7	19.6	4.7	29.9	6.0	7.8	10.2
Henderson	0.7	275.5	5.8	3.5	5.5	0.6	8.9	12.0
Cooke	3.7	95.4	5.7	2.0	0.0	0.2	3.2	11.6
Kaufman	5.0	105.8	13.4	4.6	0.9	0.8	4.2	10.2
Rockwall	1.6	3.6	4.6	1.7	0.0	0.0	0.9	2.9
Hunt	6.8	77.2	10.9	4.0	0.6	0.1	3.3	10.3
Fannin	7.1	137.0	2.8	1.4	0.0	0.0	1.9	4.7
Grayson	9.1	161.5	16.0	5.7	23.5	0.5	9.9	14.2
Perimeter 12	56.3	1369.0	115.1	41.2	112.1	11.9	102.6	123.6
Central Texas	113.5	6044.6	152.3	55.6	332.3	40.6	149.0	180.3
East Texas	16.2	4901.6	184.7	79.2	355.6	52.4	143.2	173.2
South Texas	228.6	2109.1	382.2	161.9	457.0	64.3	255.2	431.4
HGBPA	19.9	1772.3	387.1	158.7	704.8	254.0	252.0	296.7
West Texas	525.9	6203.2	282.4	112.2	285.3	38.4	427.8	598.8
AR	132.3	13782.8	232.0	139.6	428.4	93.8	339.1	477.0
LA	108.5	10085.1	377.3	217.8	1177.1	235.9	1023.4	581.6
OK	225.6	7988.2	358.2	240.9	668.0	97.2	397.4	420.7
Other States	1975.7	66127.3	3369.8	2071.2	11844.3	2148.2	3278.5	5170.5
Total	3428.9	120600.4	6202.2	3430.5	16476.4	3064.2	6558.3	8698.0

* Other anthropogenic emissions are area sources plus off-road mobile sources.

Table 2-9. Ratio of 2007 to 1999 model ready emissions for Tuesday August 17th by source region and category.

2010/1999	Bio		On Road		All Points		Other Anthropogenic *	
Source Region	NOX	VOC	NOX	VOC	NOX	VOC	NOX	VOC
Collin	1.00	1.00	0.41	0.52	0.57	1.59	0.62	0.80
Dallas	1.00	1.00	0.35	0.46	0.30	1.04	0.82	0.95
Denton	1.00	1.00	0.39	0.51	0.52	0.65	0.96	1.16
Tarrant	1.00	1.00	0.36	0.49	0.32	0.78	0.84	1.04
Core	1.00	1.00	0.36	0.48	0.33	0.90	0.82	0.98
Wise	1.00	1.00	0.42	0.50	0.93	0.98	0.54	0.91
Parker	1.00	1.00	0.33	0.43	1.01	1.09	0.31	1.11
Hood	1.00	1.00	0.46	0.55	0.67	2.02	0.24	1.11
Johnson	1.00	1.00	0.39	0.47	0.73	0.44	0.84	1.40
Ellis	1.00	1.00	0.35	0.44	1.49	1.16	1.15	1.48
Henderson	1.00	1.00	0.47	0.56	1.18	0.96	0.87	1.21
Cooke	1.00	1.00	0.49	0.45	0.55	0.24	0.91	0.96
Kaufman	1.00	1.00	0.37	0.46	7.91	2.39	0.77	1.39
Rockwall	1.00	1.00	0.50	0.44	0.00	0.00	1.07	1.26
Hunt	1.00	1.00	0.37	0.50	0.41	1.18	0.81	1.49
Fannin	1.00	1.00	0.45	0.48	0.00	0.00	0.69	1.34
Grayson	1.00	1.00	0.40	0.47	0.73	0.80	0.80	1.25
Perimeter 12	1.00	1.00	0.39	0.47	1.02	1.16	0.66	1.21
Central Texas	1.00	1.00	0.42	0.47	0.60	0.66	0.95	1.32
East Texas	1.00	1.00	0.44	0.42	0.62	0.40	0.89	1.21
South Texas	1.00	1.00	0.41	0.46	0.70	0.38	0.83	1.06
HGBPA	1.00	1.00	0.36	0.47	0.42	0.42	0.69	0.94
West Texas	1.00	1.00	0.46	0.50	0.80	0.52	0.93	1.10
AR	1.00	1.00	0.51	0.43	0.90	1.32	0.92	0.76
LA	1.00	1.00	0.48	0.44	0.89	1.05	0.95	0.66
OK	1.00	1.00	0.49	0.42	1.02	1.72	0.61	0.72
Other States	1.00	1.00	0.53	0.47	0.53	0.83	1.00	0.74
Total	1.00	1.00	0.48	0.46	0.59	0.84	0.93	0.82

* Other anthropogenic emissions are area sources plus off-road mobile sources.

Table 2-10. Emissions source area definitions.

Area Number	Area Abbreviation	Area Definition
1-4	Core	Dallas Core Counties (Collin, Dallas, Denton, Tarrant)
5-16	Perimeter12	12 Counties surrounding Dallas Core (Wise, Parker, Hood Johnson, Ellis, Henderson, Cooke, Kaufman, Rockwall, Hunt, Fannin, Grayson)
17	East Texas	Northeast Texas
18	HGBPA	Houston/Galveston/Beaumont/Port-Arthur (11 Counties)
19	Central Texas	East Central Texas
20	OK	Oklahoma
21	AR	Arkansas
22	LA	Louisiana
23	South Texas	Near Non-attainment areas (Austin, San Antonio, Victoria, Corpus Christi)
24	West Texas	Texas (excluding area 1-19 and 23)
25	Other States	Other areas

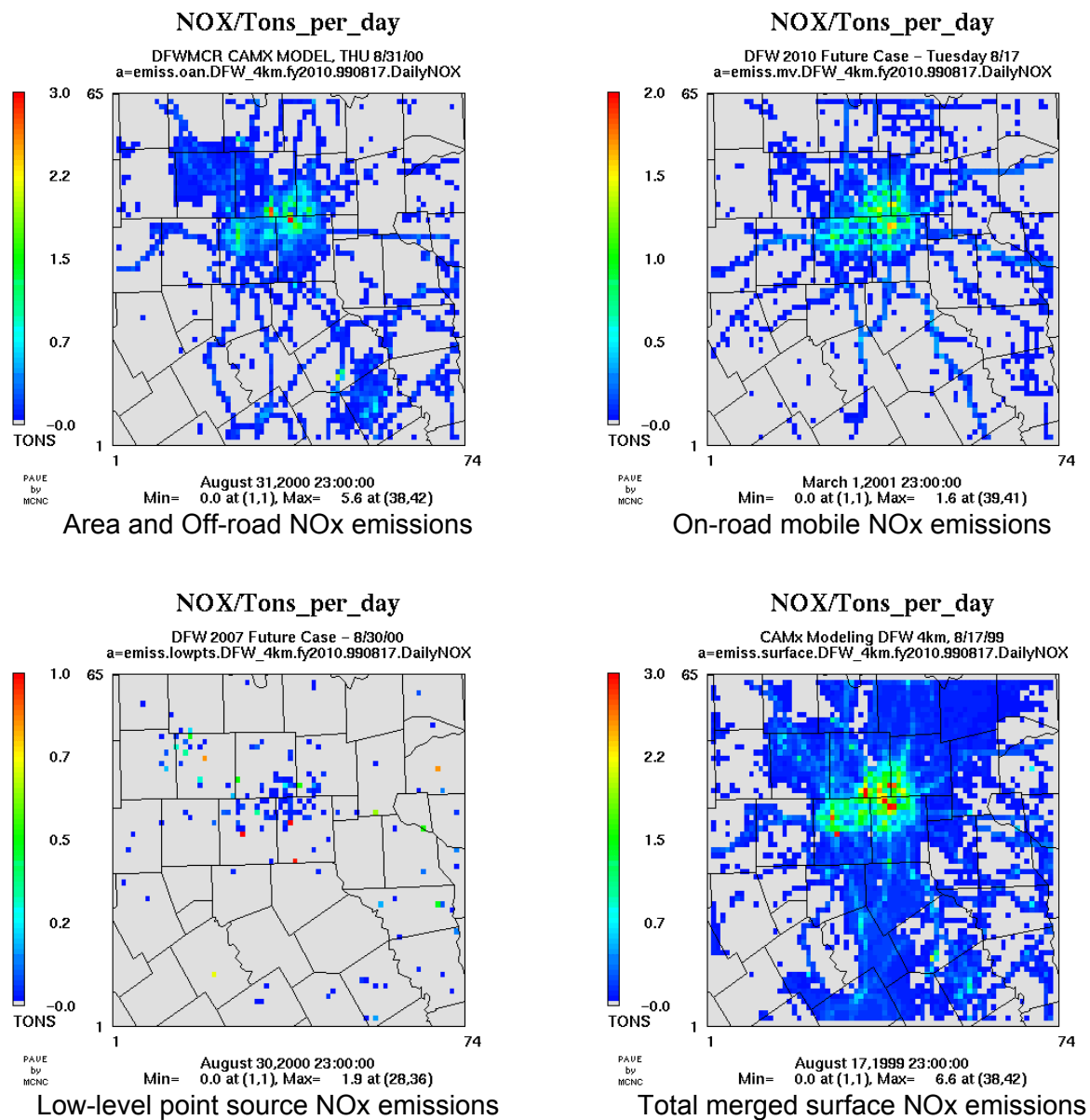


Figure 2-2. 2010 NOx emissions for Tuesday August 17th on the 4-km grid.

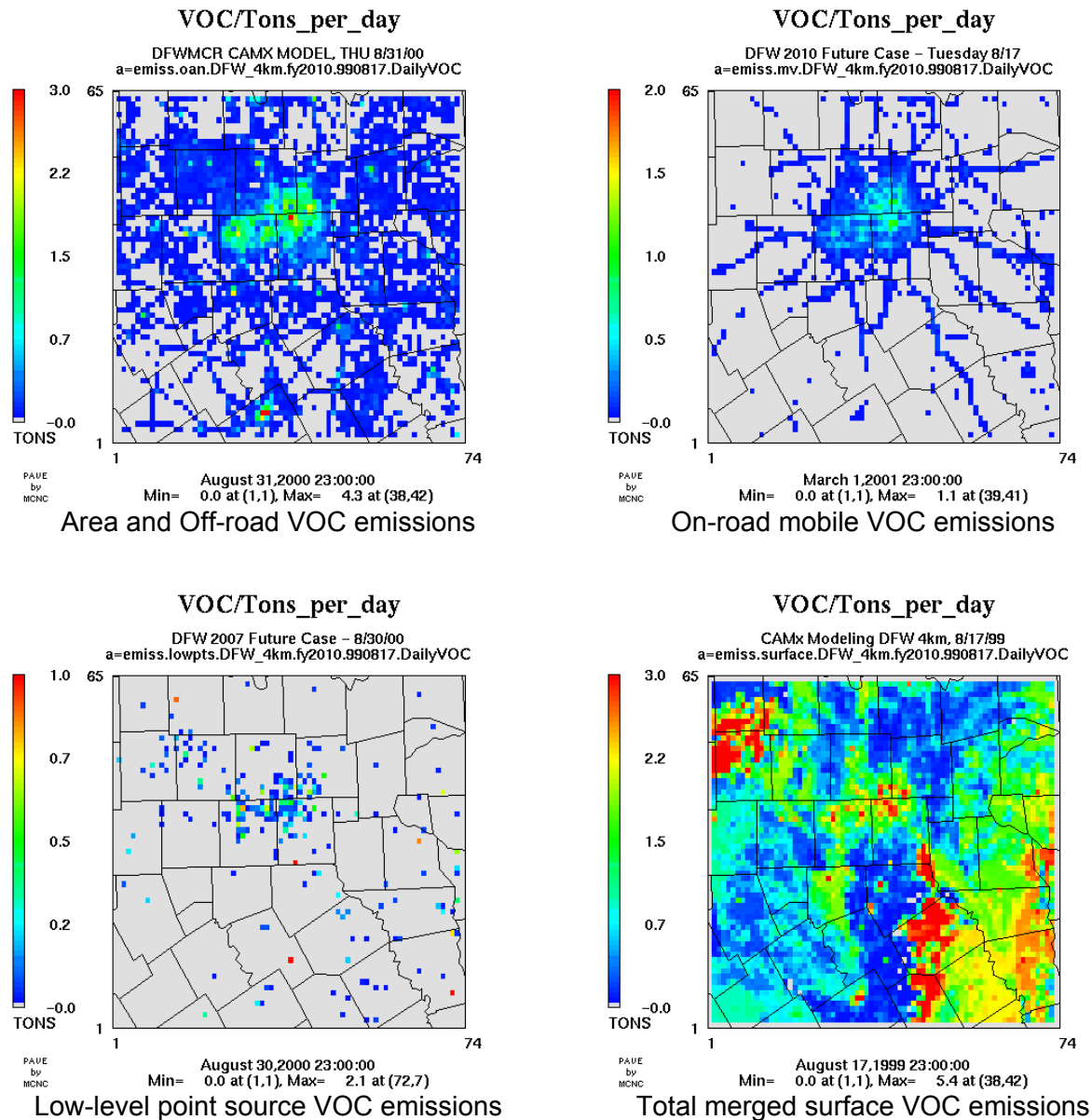


Figure 2-3. 2010 VOC emissions for Tuesday August 17th on the 4-km grid.

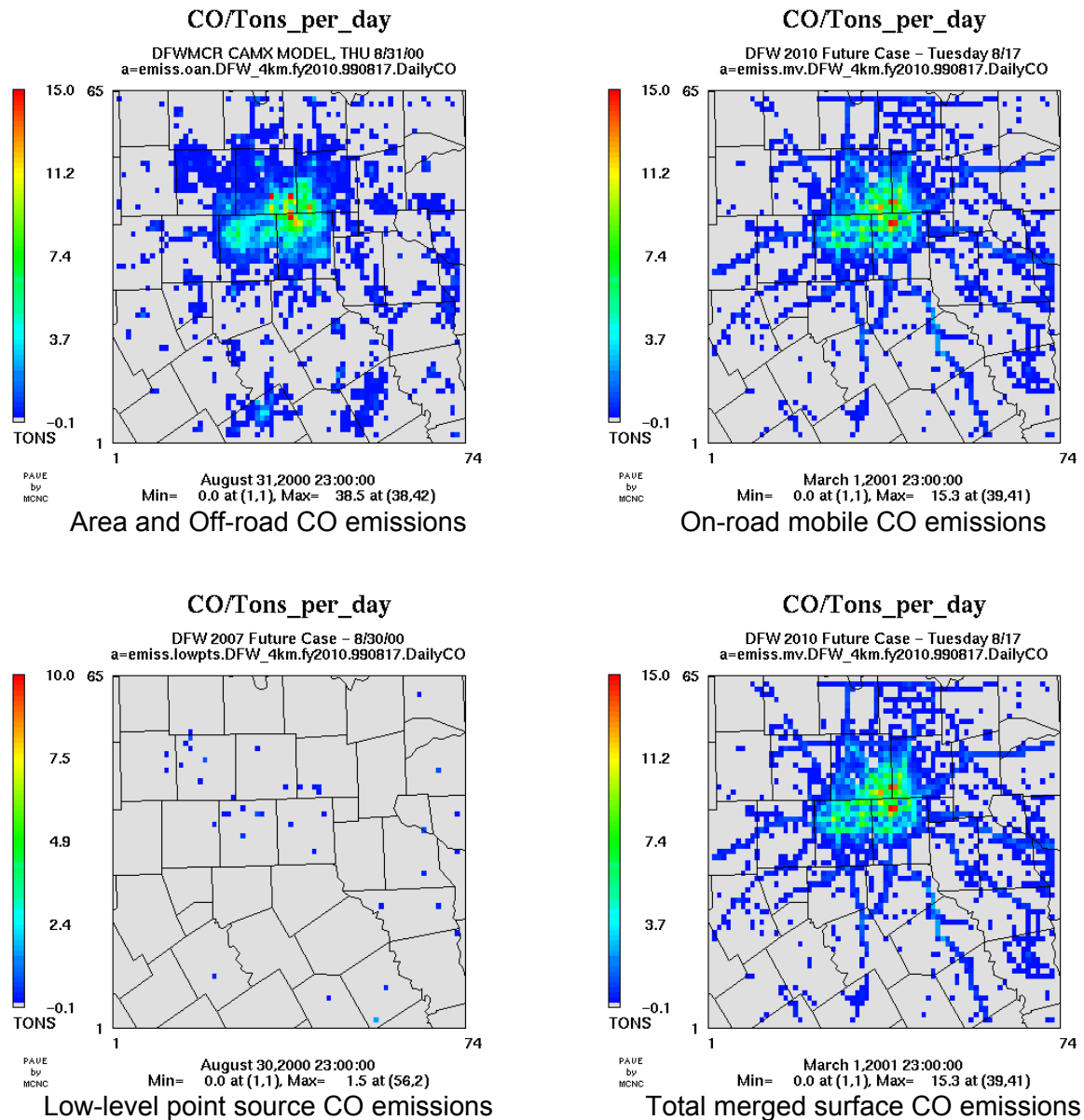


Figure 2-4. 2010 CO emissions for Tuesday August 17th on the 4-km grid.

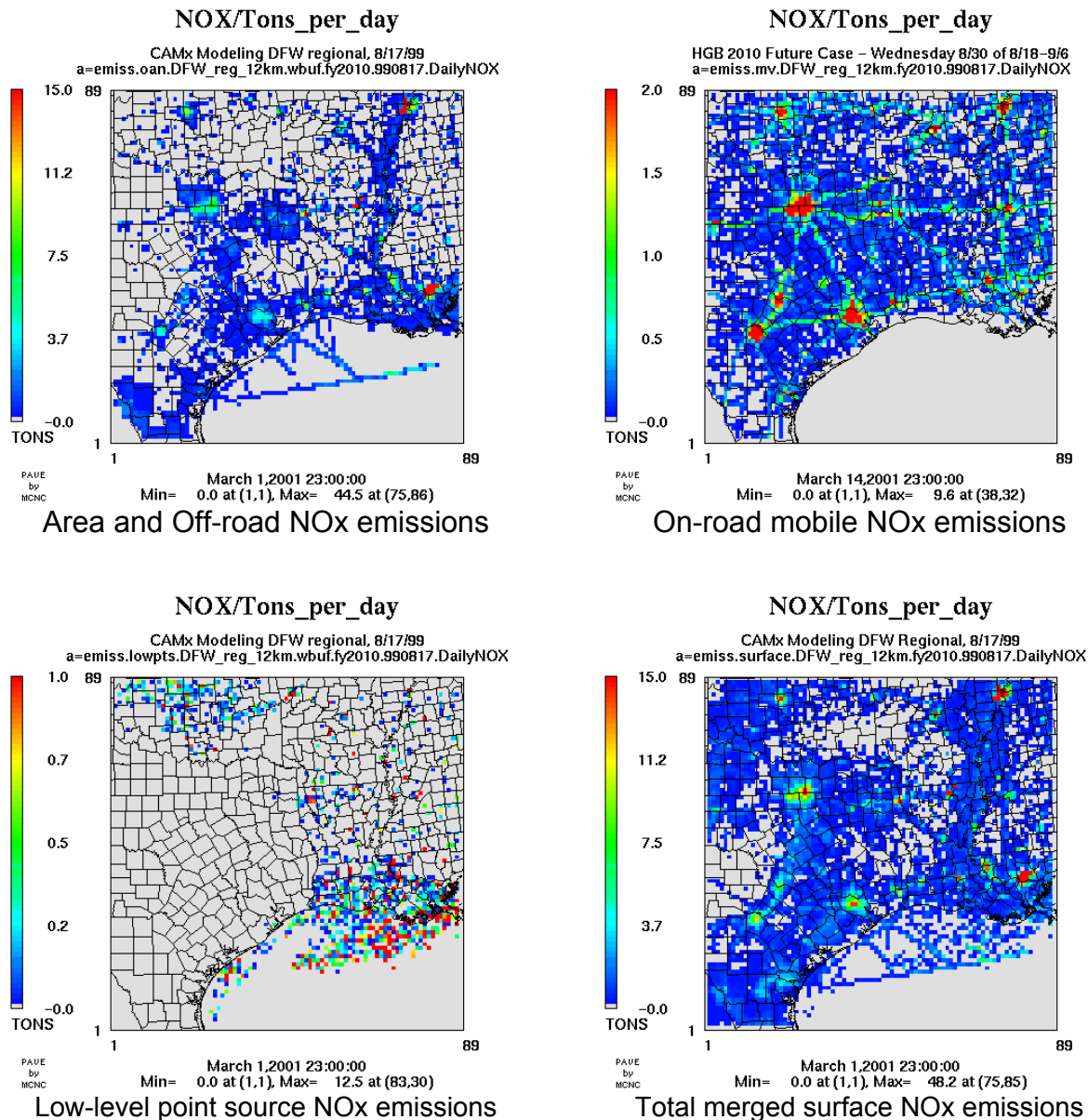


Figure 2-5. 2010 NOx emissions for Tuesday August 17th on the 12-km emissions grid.

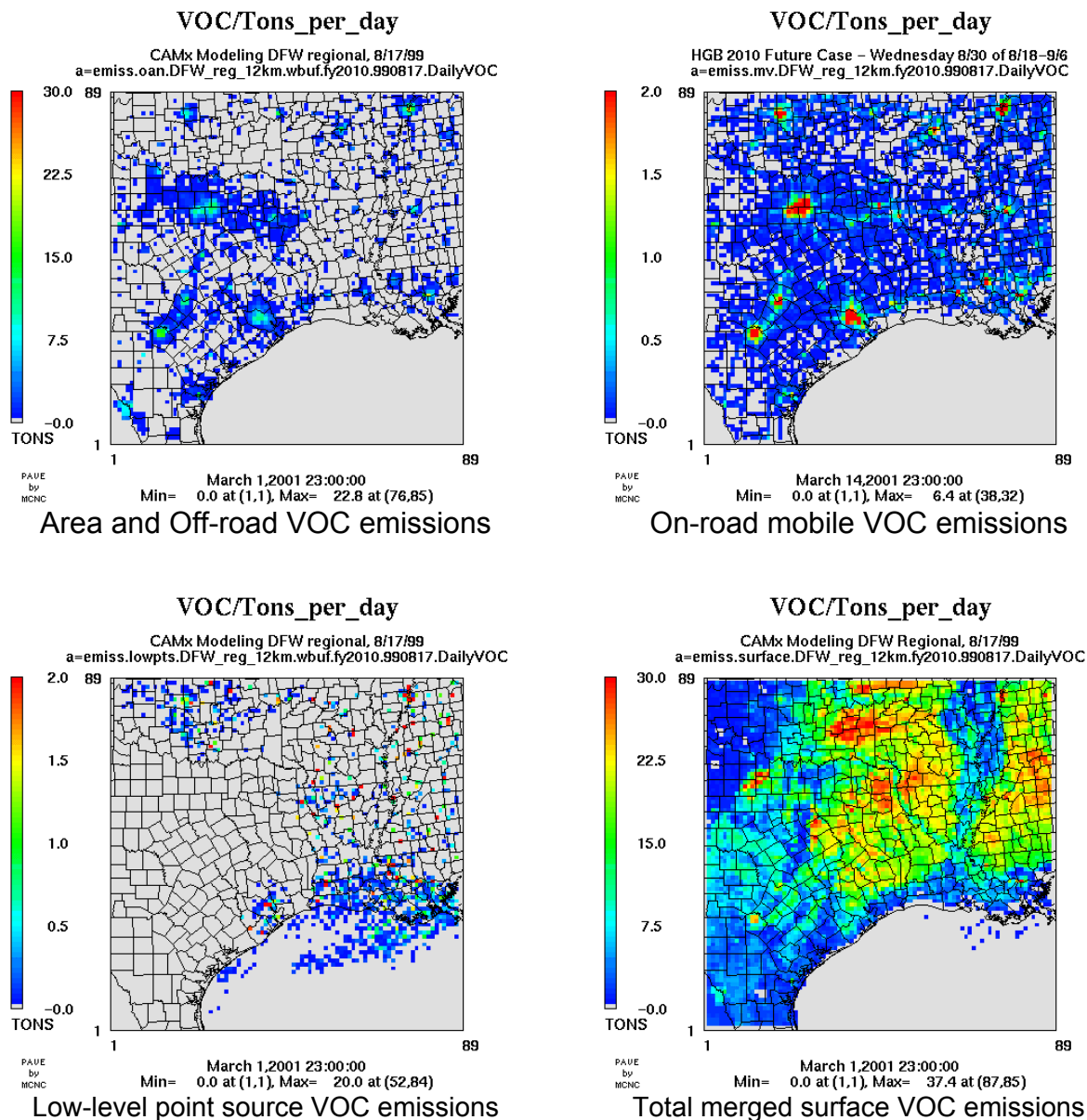


Figure 2-6. 2010 VOC emissions for Tuesday August 17th on the 12-km emissions grid.

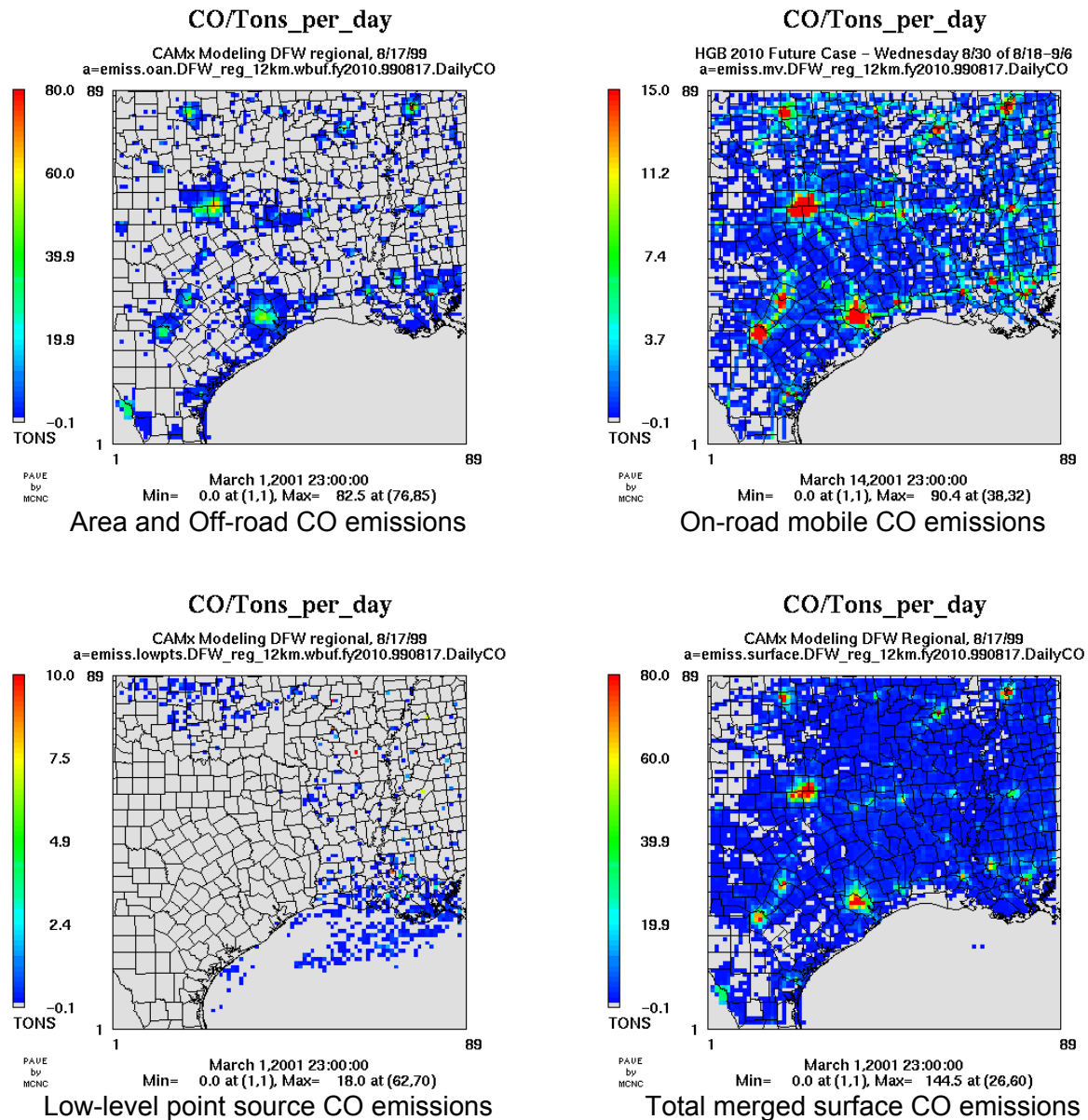


Figure 2-7. 2010 CO emissions for Tuesday August 17th on the 12-km emissions grid.

3.0 OZONE MODELING

CAMx MODEL CONFIGURATION AND INPUTS

Previous CAMx modeling of the Dallas/Fort Worth August 1999 ozone episode described by Mansell et al. (2003) used version 4.02 of the CAMx model. The current 2007 future year modeling uses CAMx version 4.03. CAMx 4.03 includes only a few changes from CAMx 4.02 (see the model release notes posted at <http://www.camx.com>), but one change corrects an error in the calculation of dry deposition velocities and results in slightly lower ozone levels (a few ppb) with CAMx 4.03 than CAMx 4.02 for the DFW modeling. The 1999 base year modeling was re-run with CAMx 4.03 to provide consistent base and future year simulation results for subsequent analysis. The input data requirements are the same for CAMx versions 4.02 and 4.03 so that updating the 1999 modeling to the new CAMx version does not require any changes to input data or files.

All of the CAMx meteorological input data were derived from the Fifth Generation Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5; Duhdia, 1993). The MM5 modeling used nested 108-km, 36-km, 12-km and 4-km grids and 28 vertical layers. An analysis of the meteorological modeling performed in support of the initial 1999 DFW air quality modeling efforts, and the final MM5 run used for air quality modeling of the DFW 1999 episode (denoted Run3), is documented in ENVIRON, 2003, and Mansell et al., (2003). Additional MM5 modeling was performed under contract to TCEQ with the goal of improving the meteorological modeling and subsequent air quality modeling results. These efforts are documented in Emery et al., 2004. The final MM5 run used in the updated 1999 air quality modeling simulations, as well as the 2010 future year CAMx simulations documented herein, is denoted Run5.

CAMx has several user-selectable options that are specified for each simulation through the CAMx control file. Most of these options follow naturally from other choices about model inputs. There are four model options that must be decided for each project: the choice of the chemical mechanism, the chemistry solver, advection scheme, and the plume-in-grid scheme. The selection for each option is decided at the stage of the base case model performance evaluation and then held fixed for the evaluation of any future year emission scenarios. The CAMx model configuration and inputs used for both the 1999 and 2007 modeling were documented in Mansell, et al., (2003), and briefly summarized below.

Chemistry Data

The chemistry parameters file specifies the photochemical mechanism used to model ozone formation as well as the rates for all thermo-chemical reactions associated with the chemical mechanism.

- CAMx was run with an updated version of the Carbon Bond 4 mechanism (CB4), referred to as mechanism 3 in CAMx, which is described in the CAMx User's Guide (ENVIRON, 2002). Mechanism 3 is the CB4 mechanism with updated radical-radical termination reactions and updated isoprene mechanism as used for the OTAG modeling and other TCEQ modeling studies.

- CAMx has two options for the numerical scheme used to solve the chemical mechanism. The first option is the CMC fast solver that has been used in every prior version of CAMx. The second option is an IEH solver. The CMC solver is faster and more accurate than most chemistry solvers used for ozone modeling. The IEH solver is even more accurate than the CMC solver, but slower. The CMC solver was used for this study.
- The CB4 mechanism also includes several “photolysis” reactions that depend upon the presence of sunlight. The photolysis rates input file determines the rates for chemical reactions in the mechanism that are driven by sunlight. Photolysis rates were calculated using the Tropospheric visible Ultra-Violet (TUV) model developed by the National Center for Atmospheric Research (Madronich, 1993 and 2002). TUV is a state-of-the-science solar radiation model that is designed for photolysis rate calculations. TUV accounts for environmental parameters that influence photolysis rates including solar zenith angle, altitude above the ground, surface UV albedo, aerosols (haze), and stratospheric ozone column.

Advection Scheme

CAMx version 4.03 has three optional methods for calculating horizontal advection called Smolarkiewicz, Bott and Piecewise Parabolic Method (PPM). Although the Smolarkiewicz scheme has been used for many years, and was used in the previous modeling for Northeast Texas (ENVIRON, 1999), the scheme has been criticized for causing too much artificial diffusion of pollutants, tending to “smear out” features and artificially overstate transport. The Bott and PPM schemes are newer and have less artificial diffusion than the Smolarkiewicz scheme. The PPM scheme was used for this study as it has been determined to be the least numerically diffusive, runs at speeds similar to Smolarkiewicz, and does not exhibit certain “noisy” features near sharp gradients that are apparent with the Bott approach.

Plume-in-Grid

CAMx includes an optional sub-grid scale plume model that can be used to represent the dispersion and chemistry of major NO_x point source plumes close to the source. We used the Plume-in-Grid (PiG) sub-model for major NO_x sources (i.e., point sources with episode average NO_x emissions greater than 2 tons per day in the 4-km grid and 2.5 tons per day outside the 4-km grid).

Surface Characteristics

CAMx requires gridded landuse data to characterize surface boundary conditions, such as surface roughness, deposition parameters, vegetative distribution, and water/land boundaries. CAMx land use files provide the fractional contribution (0 to 1) of eleven land use categories to the surface area of grid cell. Gridded land cover data were developed from the same landuse databases that were used in the generation of spatial emission surrogates for the 36-km and 12-km grids. The development of surface characteristics data was documented in Mansell et al. (2003)

Initial and Boundary Conditions

The initial conditions (ICs) are the pollutant concentrations specified throughout the modeling domain at the start of the simulation. Boundary conditions (BCs) are the pollutant concentrations specified at the perimeter of the modeling domain. Conventional wisdom dictates that the boundary conditions should have little impact on the model results for the DFW area because regional modeling is being performed. One of the reasons for performing regional scale modeling rather than urban scale modeling is to minimize the importance of ICs and BCs. Using a large regional domain moves the boundaries far away (in distance and transport time) from the study area.

However, the base case modeling and sensitivity tests (Mansell et al., 2003) showed that the boundary conditions do influence the modeling results for DFW non-attainment area. In particular, the amount of background VOC in air entering the modeling domain from the Midwest and Southeast influences the regional background ozone levels transported into DFW. The VOC boundary conditions are mainly influenced by biogenic emissions and so there is no reason to reduce the VOC boundary conditions from 1999 to 2007. The ozone boundary condition was set to 40 ppb for 1999 which is the commonly assumed default background level for ozone. The NO_x boundary condition for 2007 was set to 1.1 ppb which is a low value representative of rural areas. Therefore, the 2007 boundary and initial conditions were not changed from the 1999 values described in Mansell et al. (2003).

UPDATED 1999 BASE CASE

Version 4.03 of the CAMx air quality model was run for the August 1999 Dallas/Ft. Worth ozone episode using the model configuration and input described above. Both the 1999 base and 2010 future years were simulated. The 1999 base year was re-run with CAMx 4.03 to provide a consistent set of modeling results for the design value scaling analysis. Model performance was slightly degraded from the CAMx 4.02 model results as discussed in more detail in Emery et al., 2004.

OZONE MODELING RESULTS FOR 1999 AND 2010

Figures 3-1 and 3-2 present the spatial distribution of predicted 1-hour ozone concentrations within the DFW 4-km and regional 12-km modeling domains, respectively. Results for both the 1999 base and 2010 future year simulations are shown. Also shown is the difference in predicted daily maximum 1-hour and 8-hour ozone concentrations. Only the August 15 – 22 episode days are shown, as the first two days of the episode are considered “spin-up” days.

Corresponding displays for the predicted daily maximum 8-hour ozone concentrations are presented in Figures 3-3 and 3-4.

Examination of the displays on Figures 3-3 and 3-4 reveal similar patterns in the spatial distribution of elevated ozone levels between the 1999 and 2010 base case simulations. Broad regions of reductions in both 1-hour and 8-hour ozone concentrations are seen although there is a fairly large area of ozone disbenefits in the Dallas urban core. These disbenefits range from a few ppb up to approximately 13 ppb ozone for the 8-hour daily maximum in the DFW 4-km modeling domain.

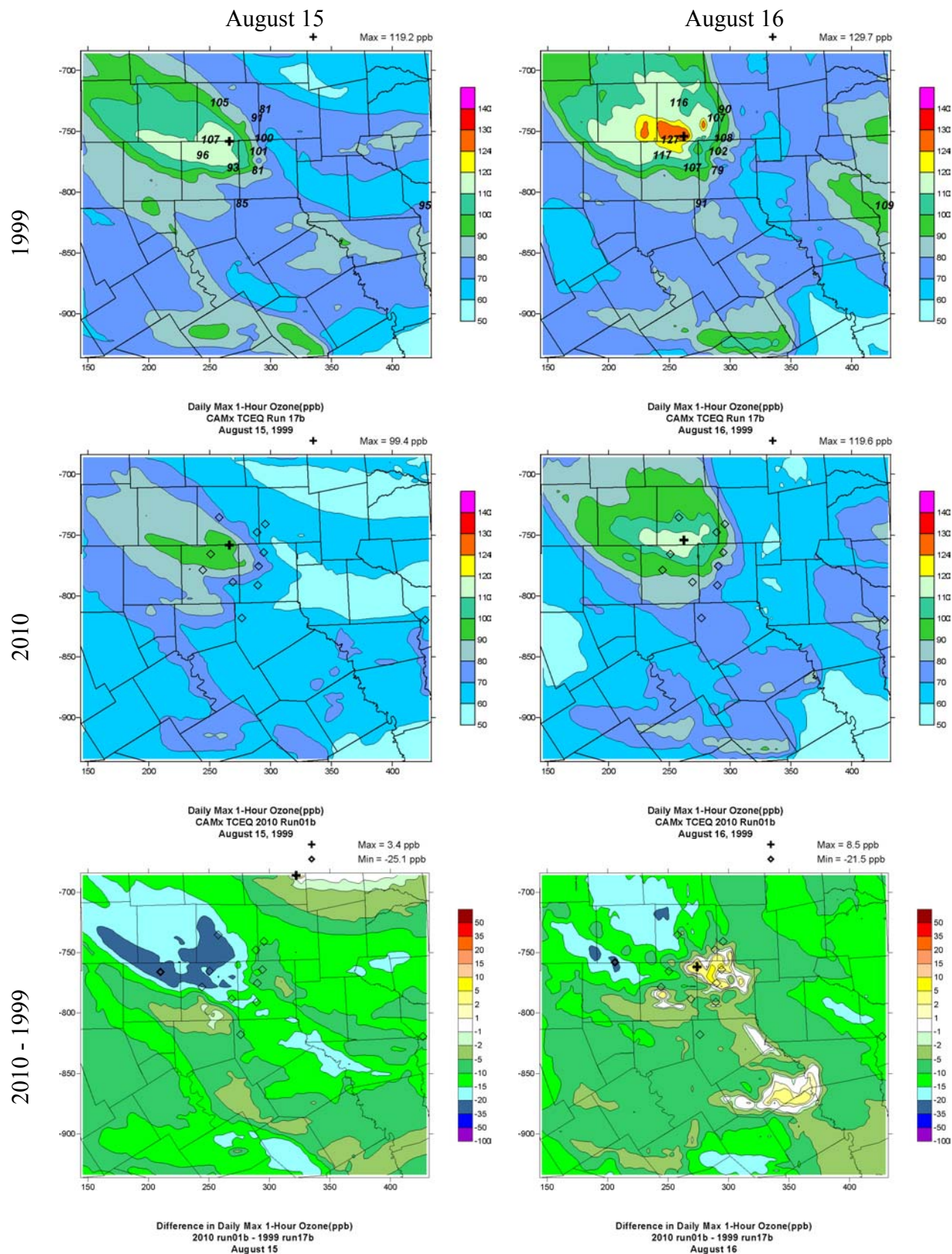


Figure 3-1. Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

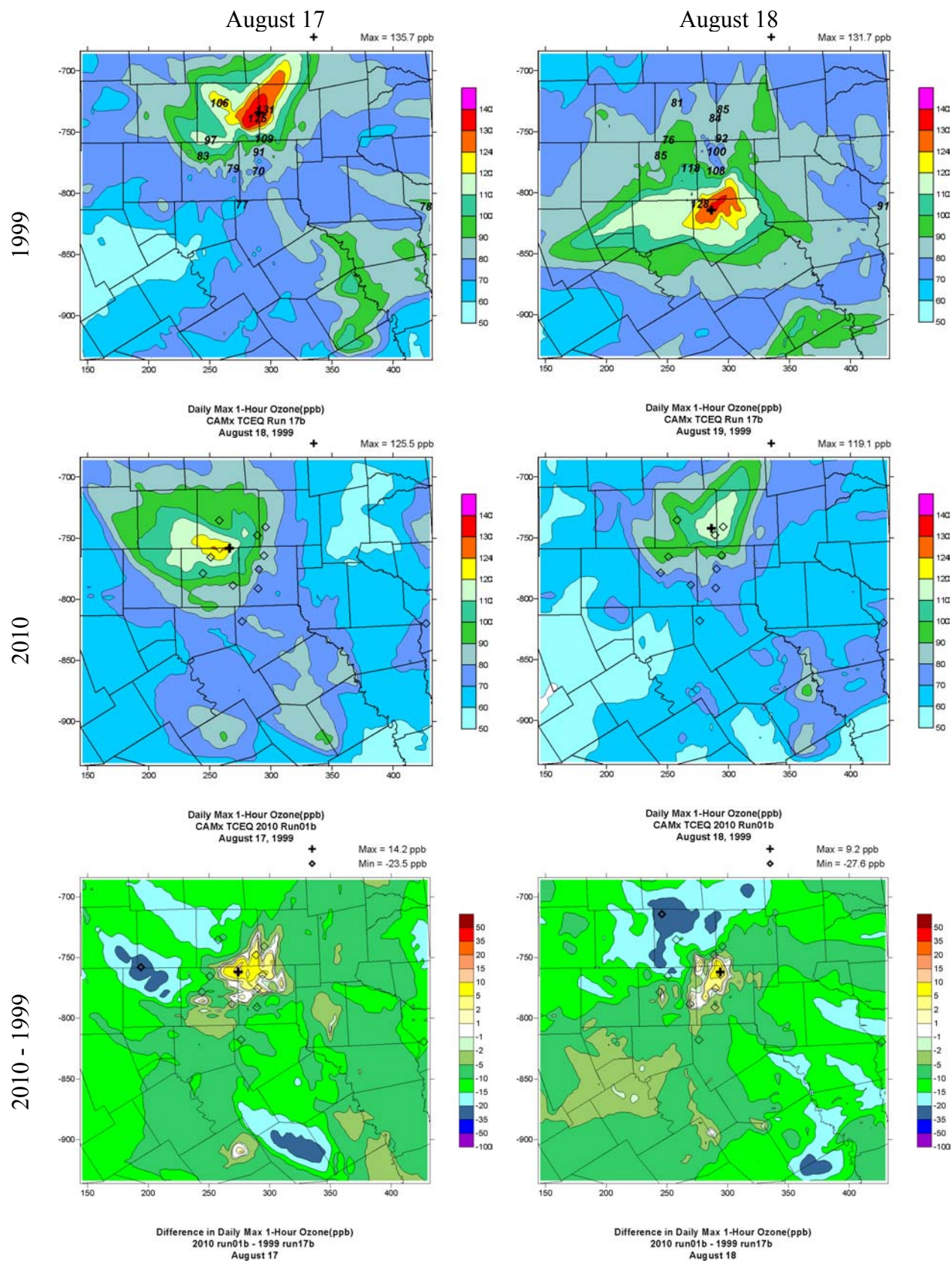


Figure 3-1 (cont.) Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

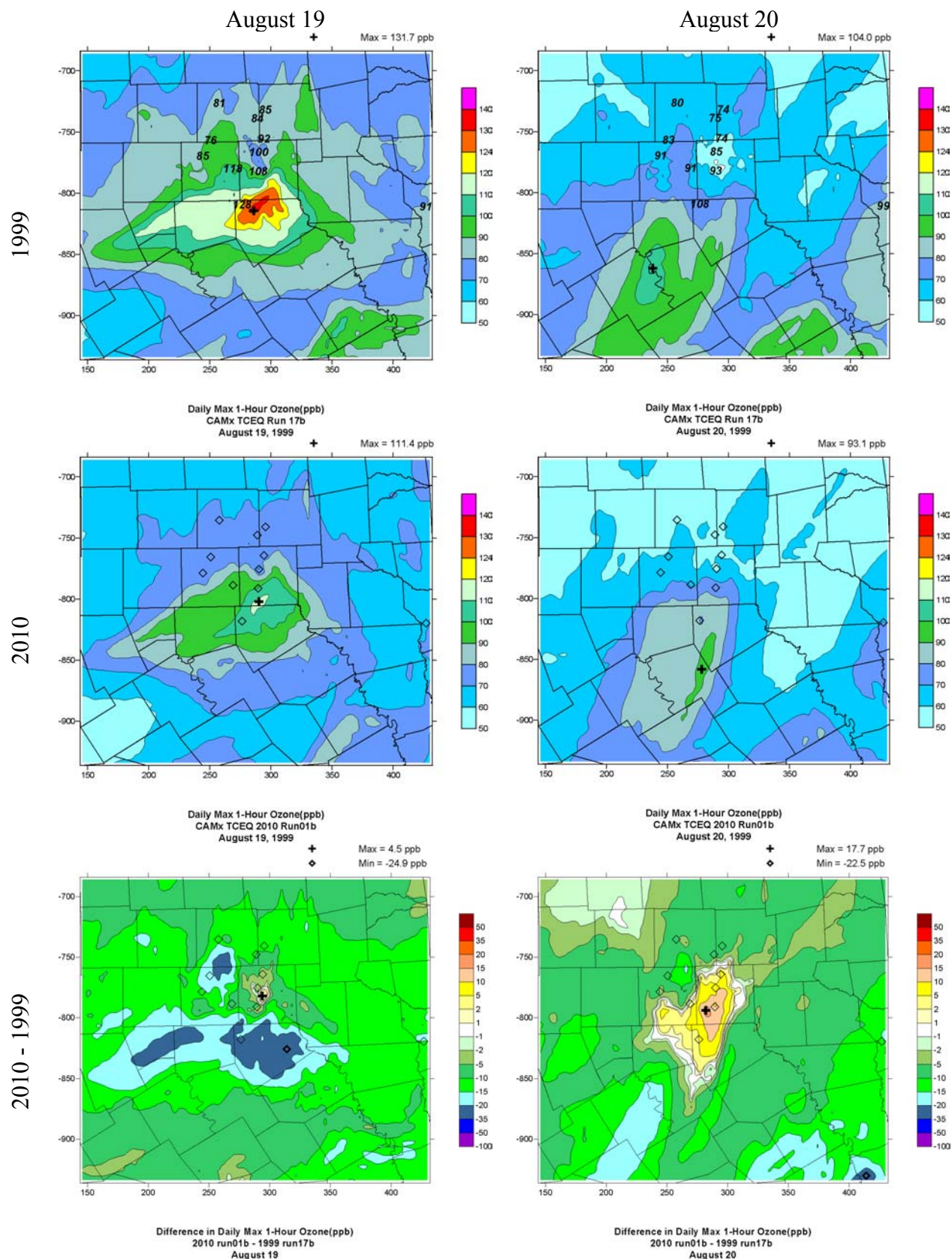


Figure 3-1 (cont.) Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

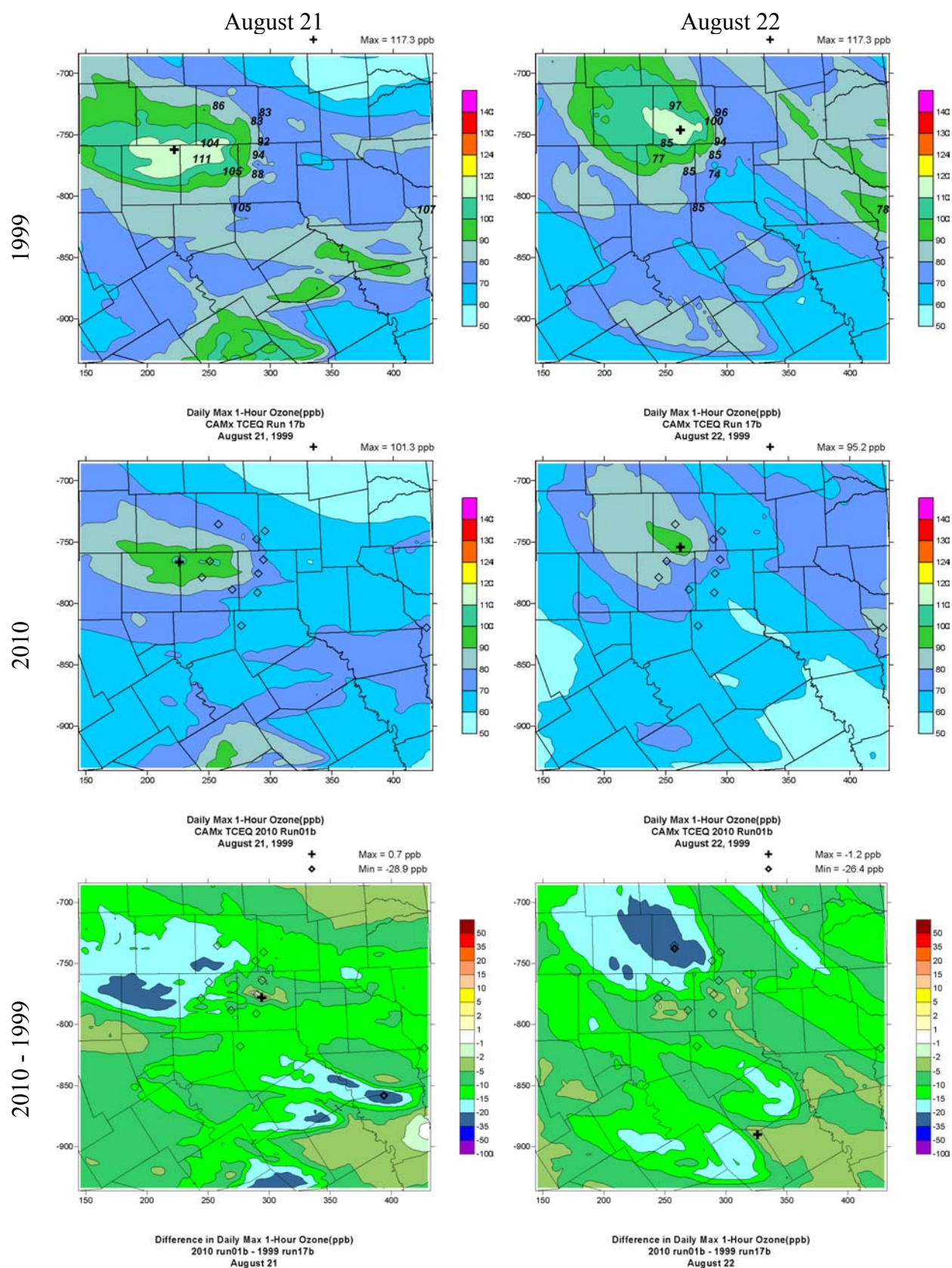


Figure 3-1 (concluded). Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

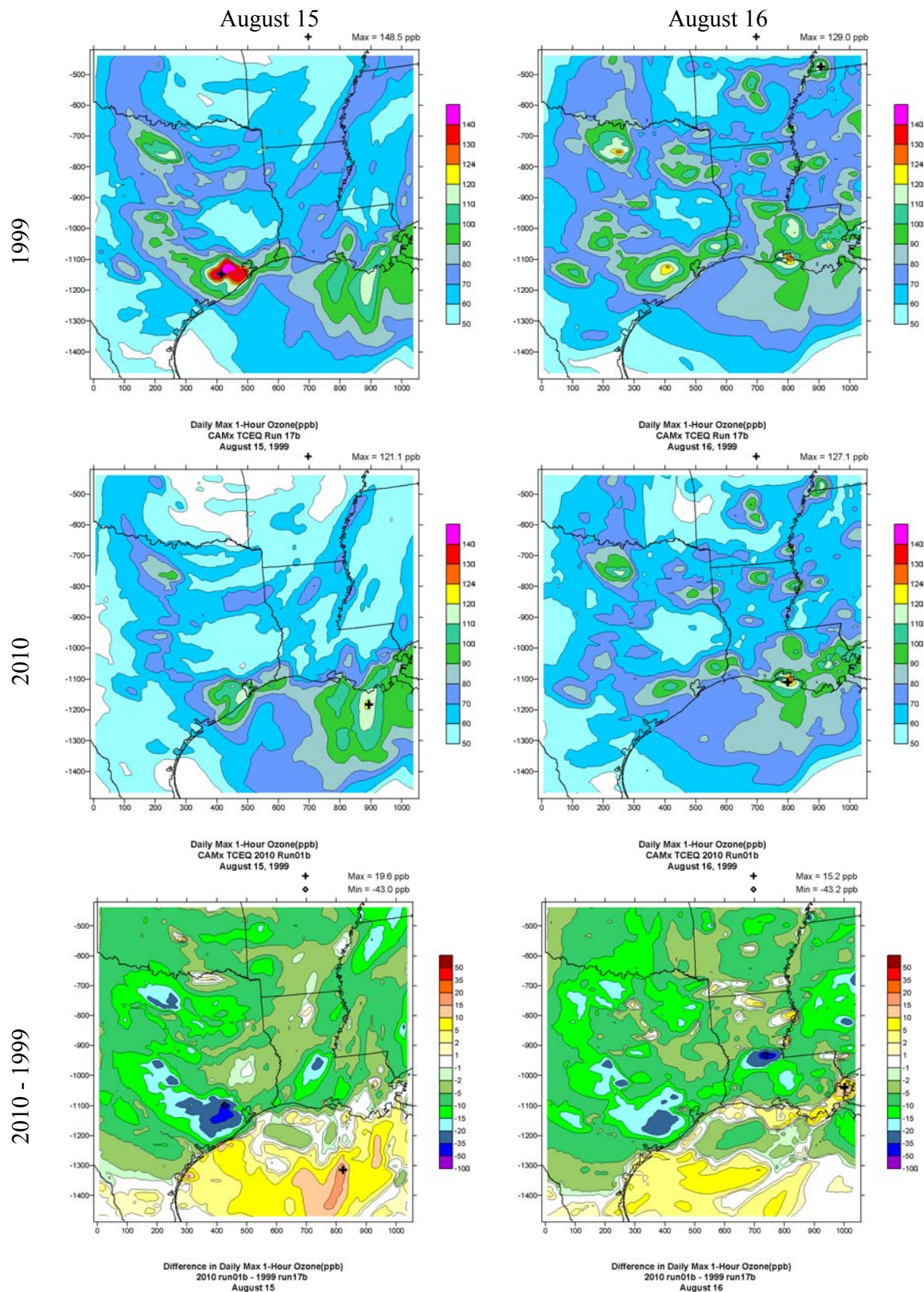


Figure 3-2. Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

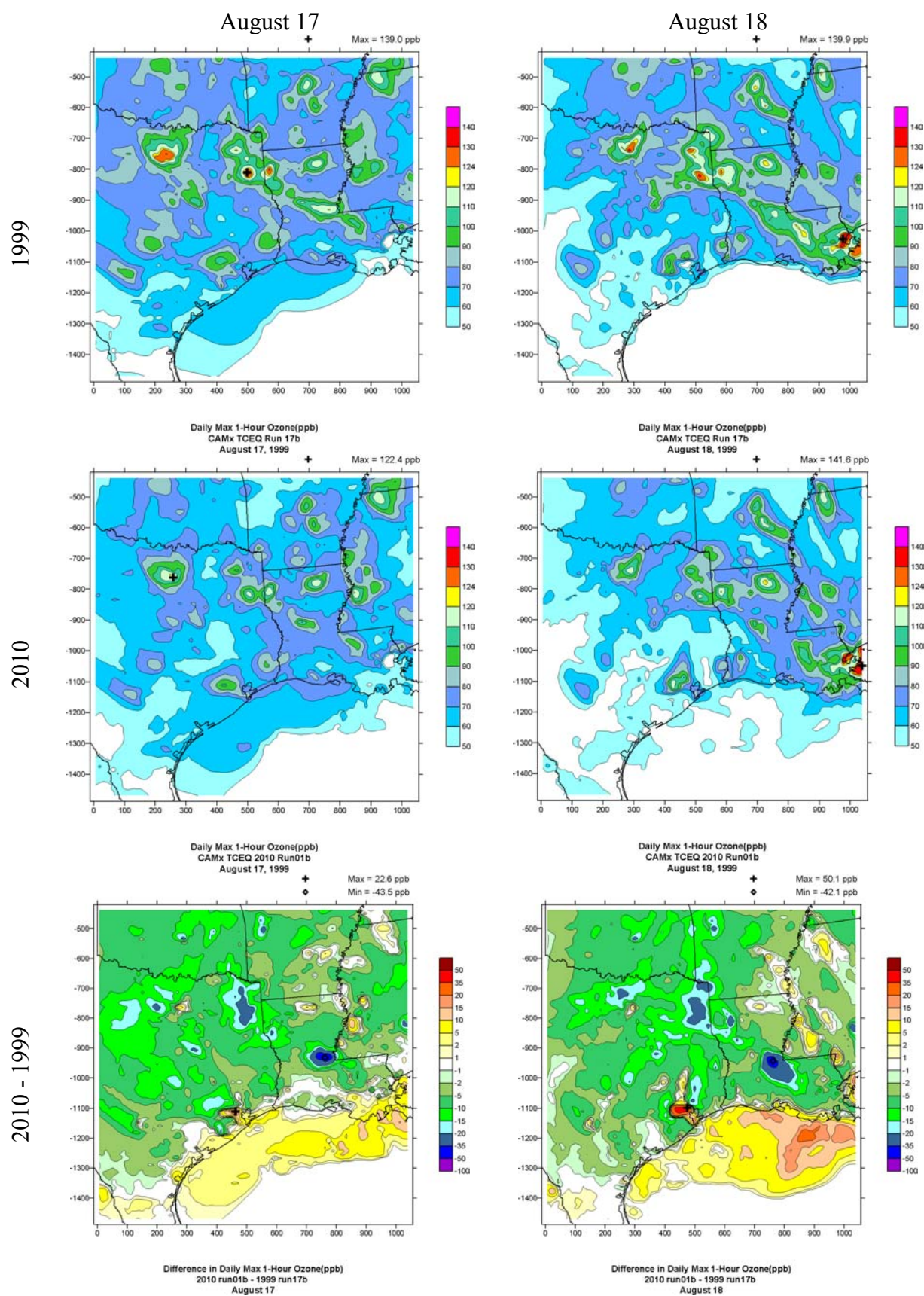


Figure 3-2. Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

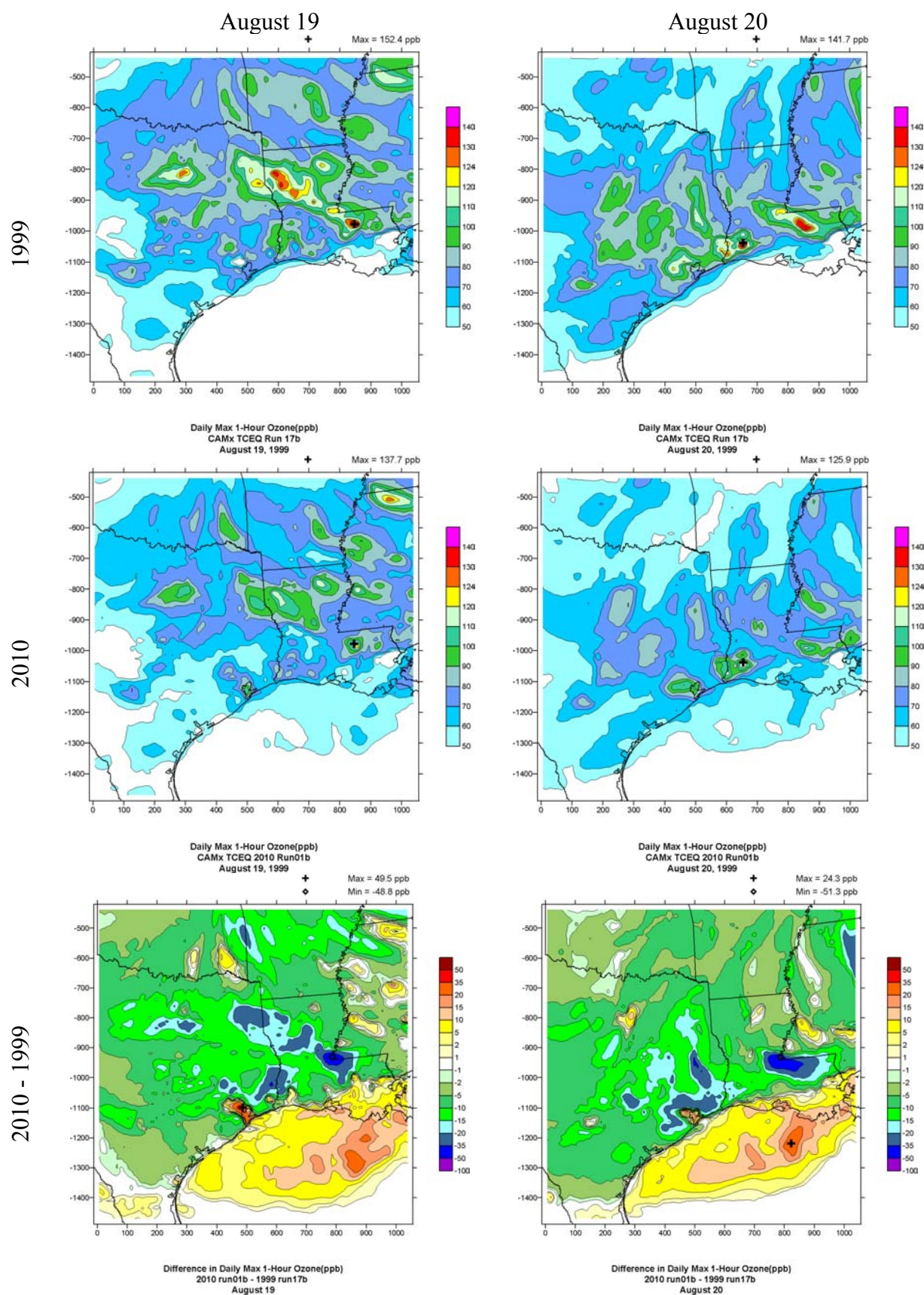


Figure 3-2. Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

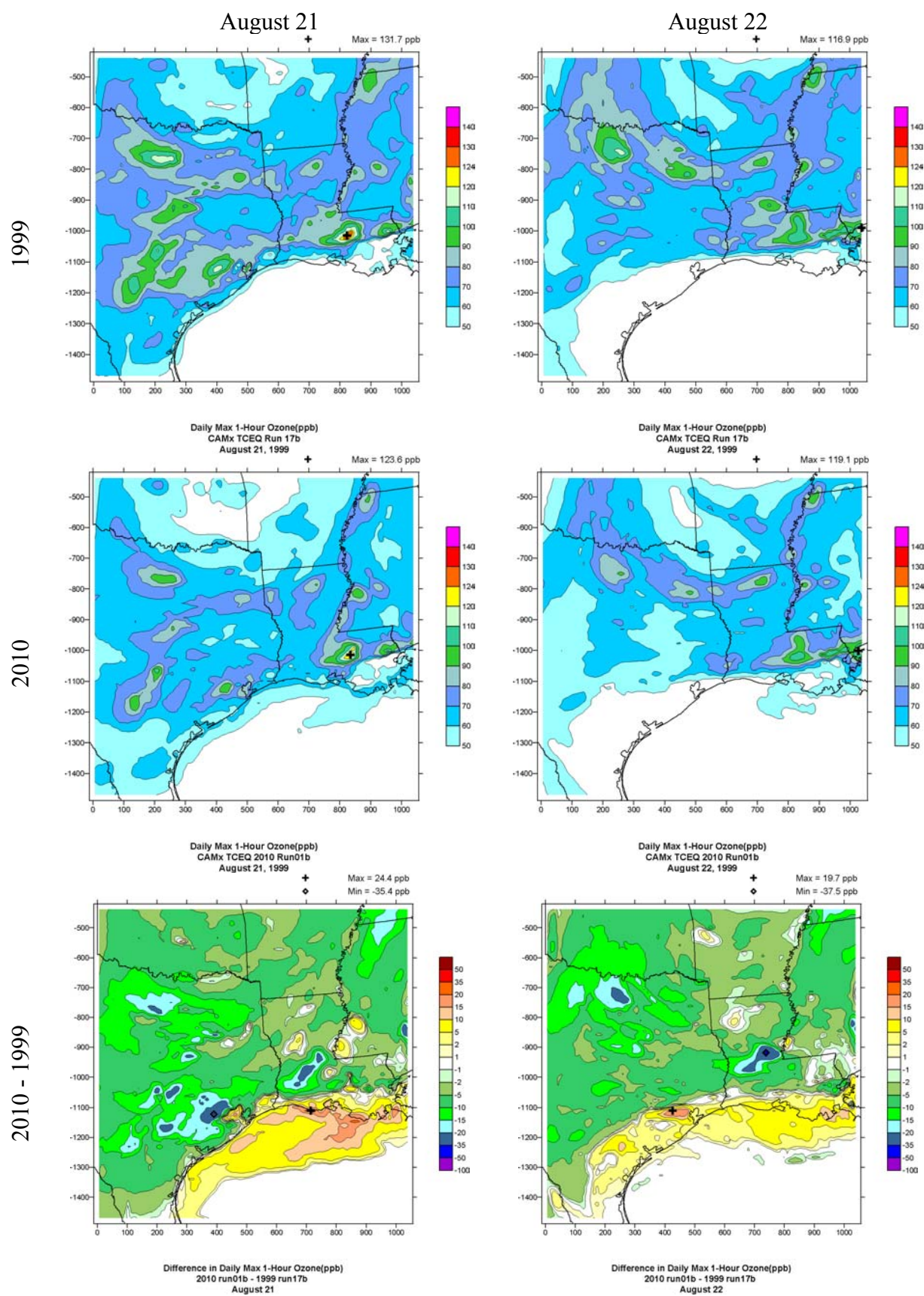


Figure 3-2. Daily maximum 1-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

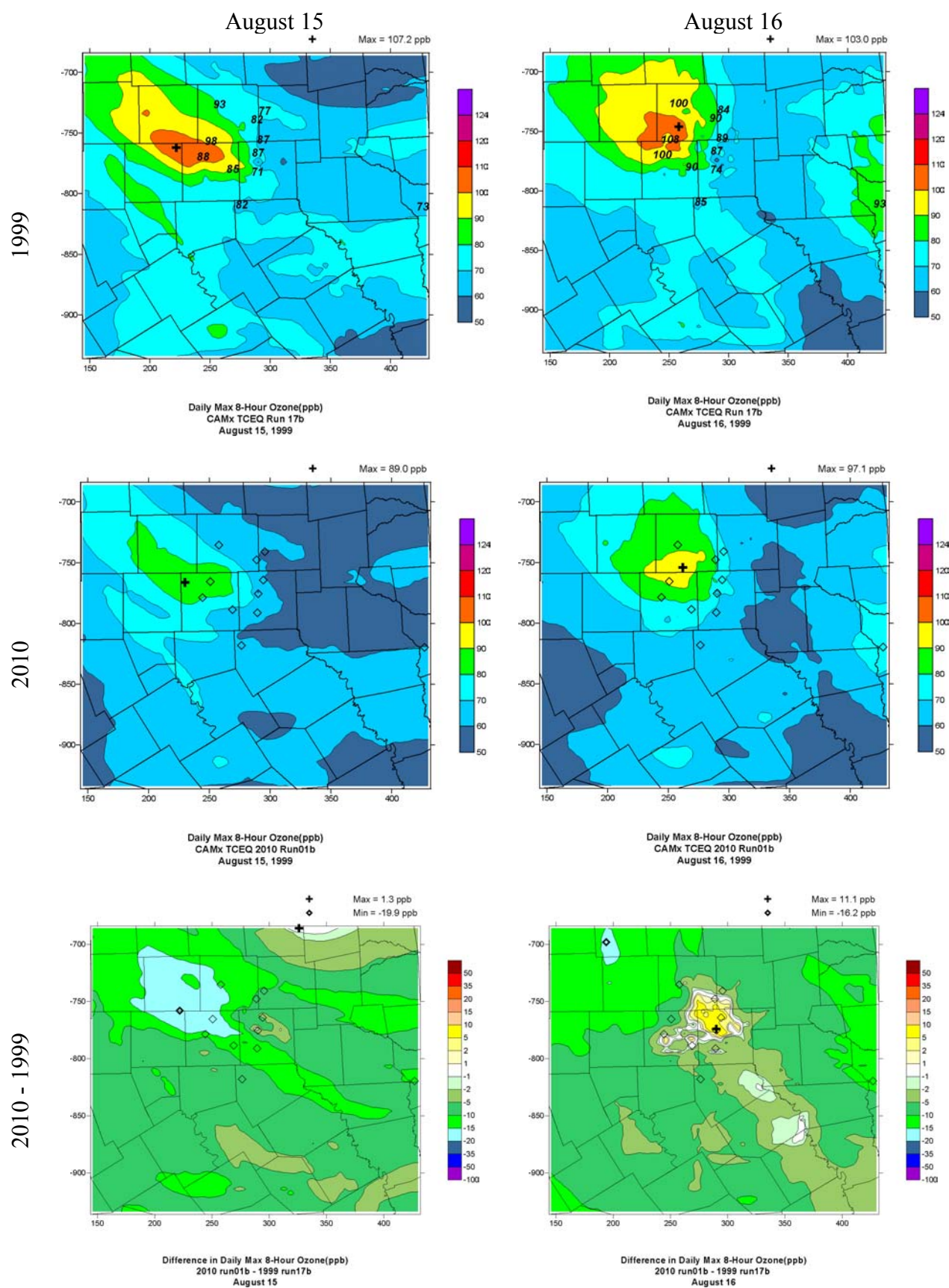


Figure 3-3. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

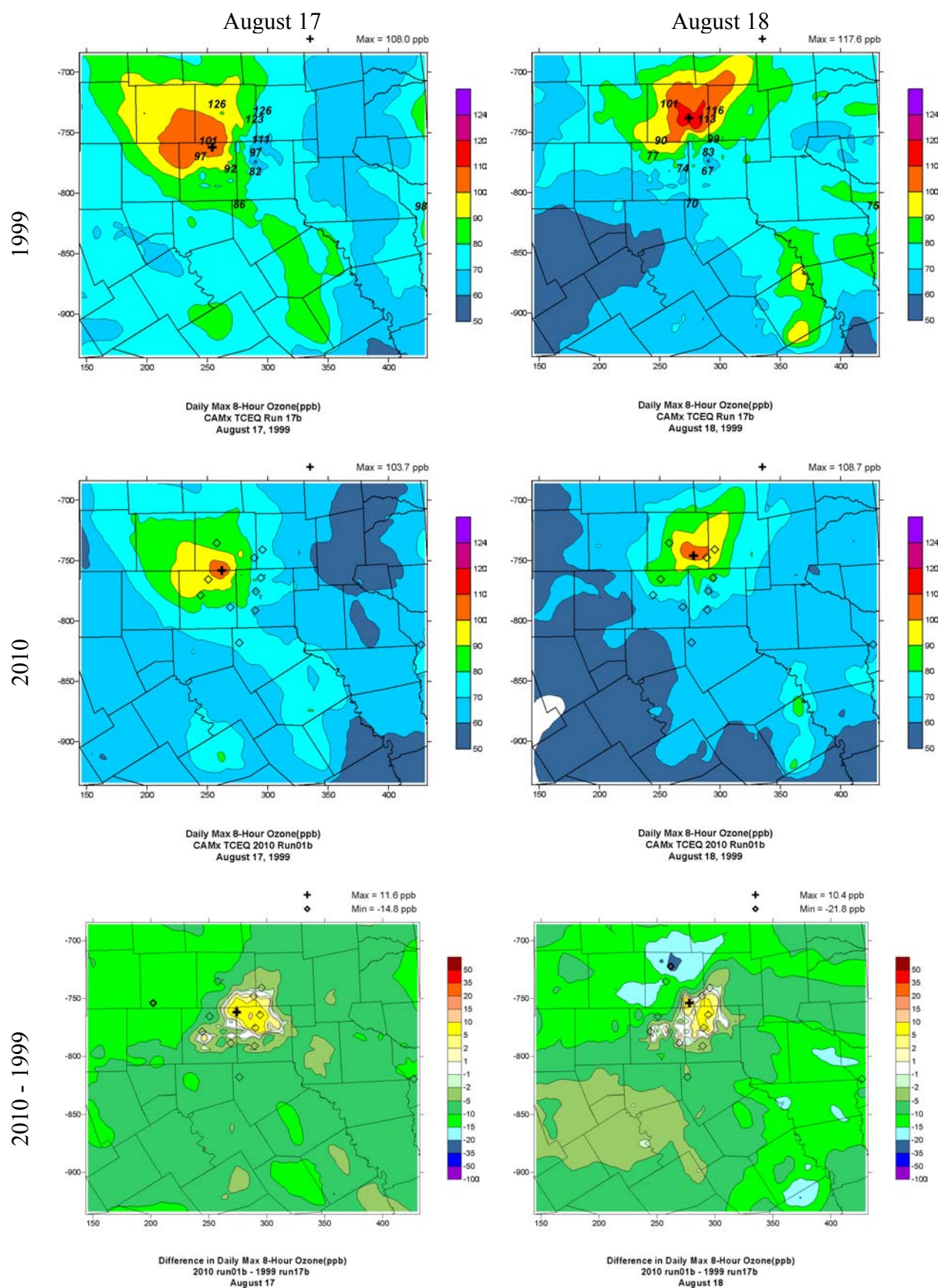


Figure 3-3. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

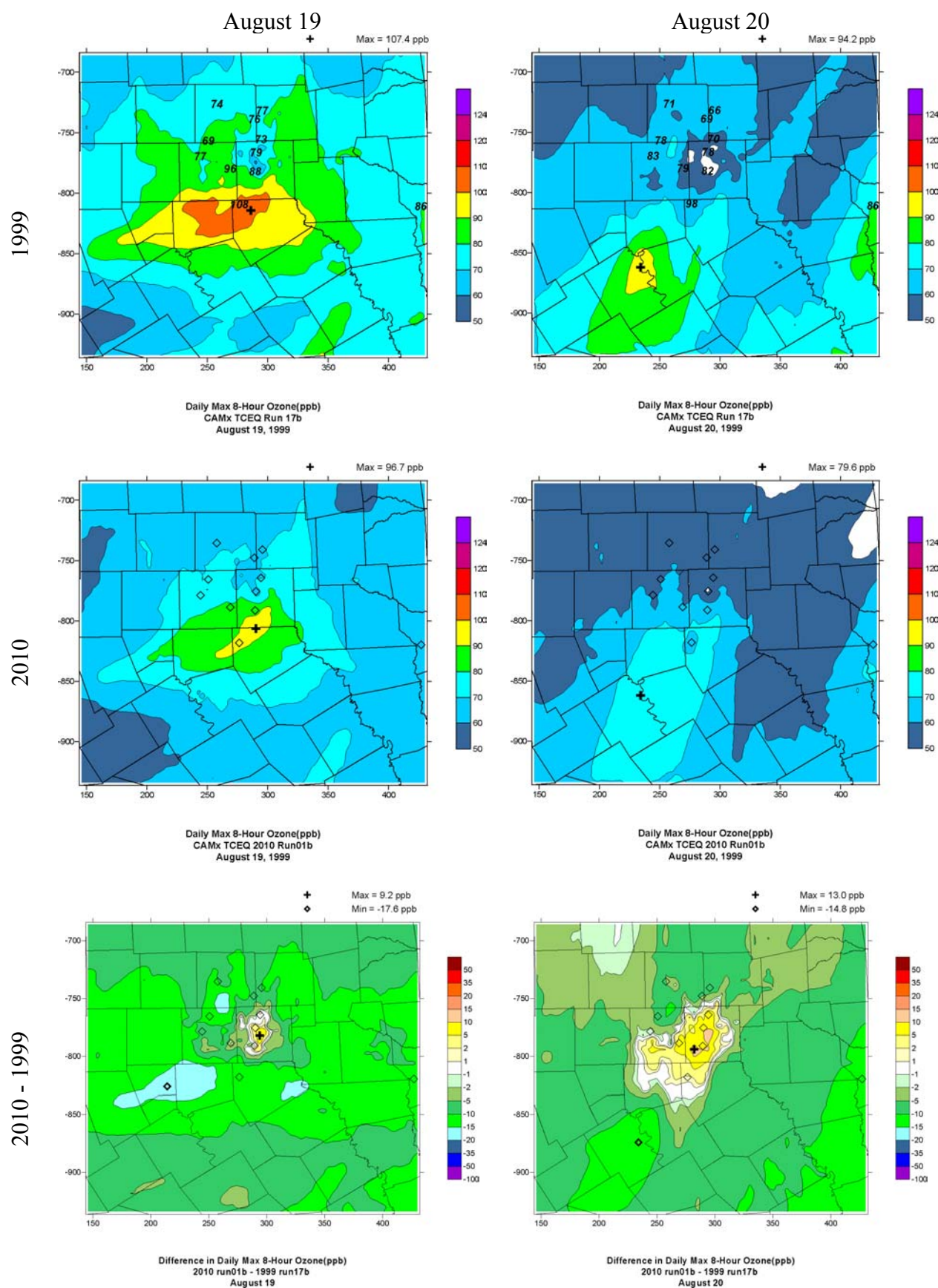


Figure 3-3. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

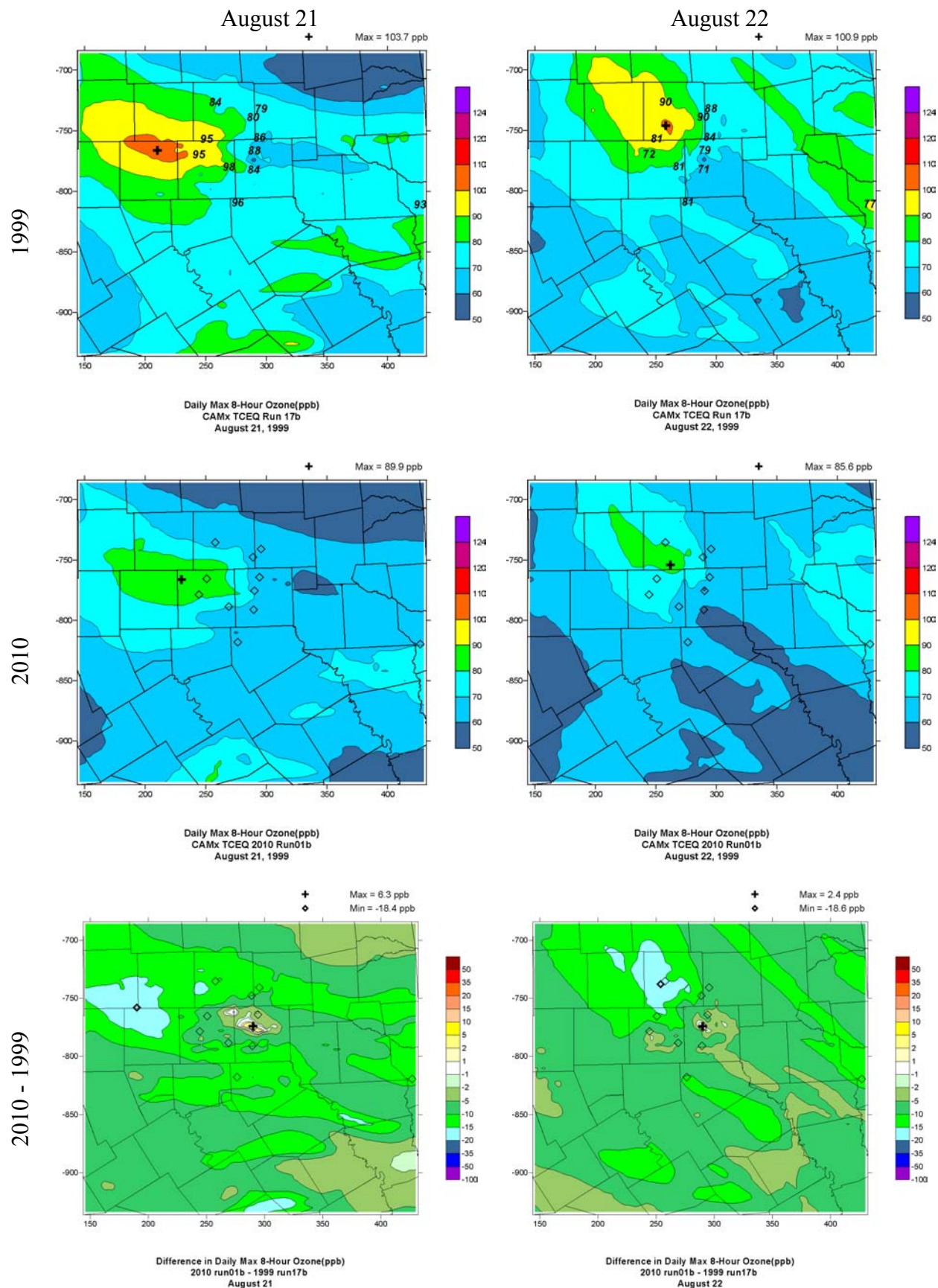


Figure 3-3. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

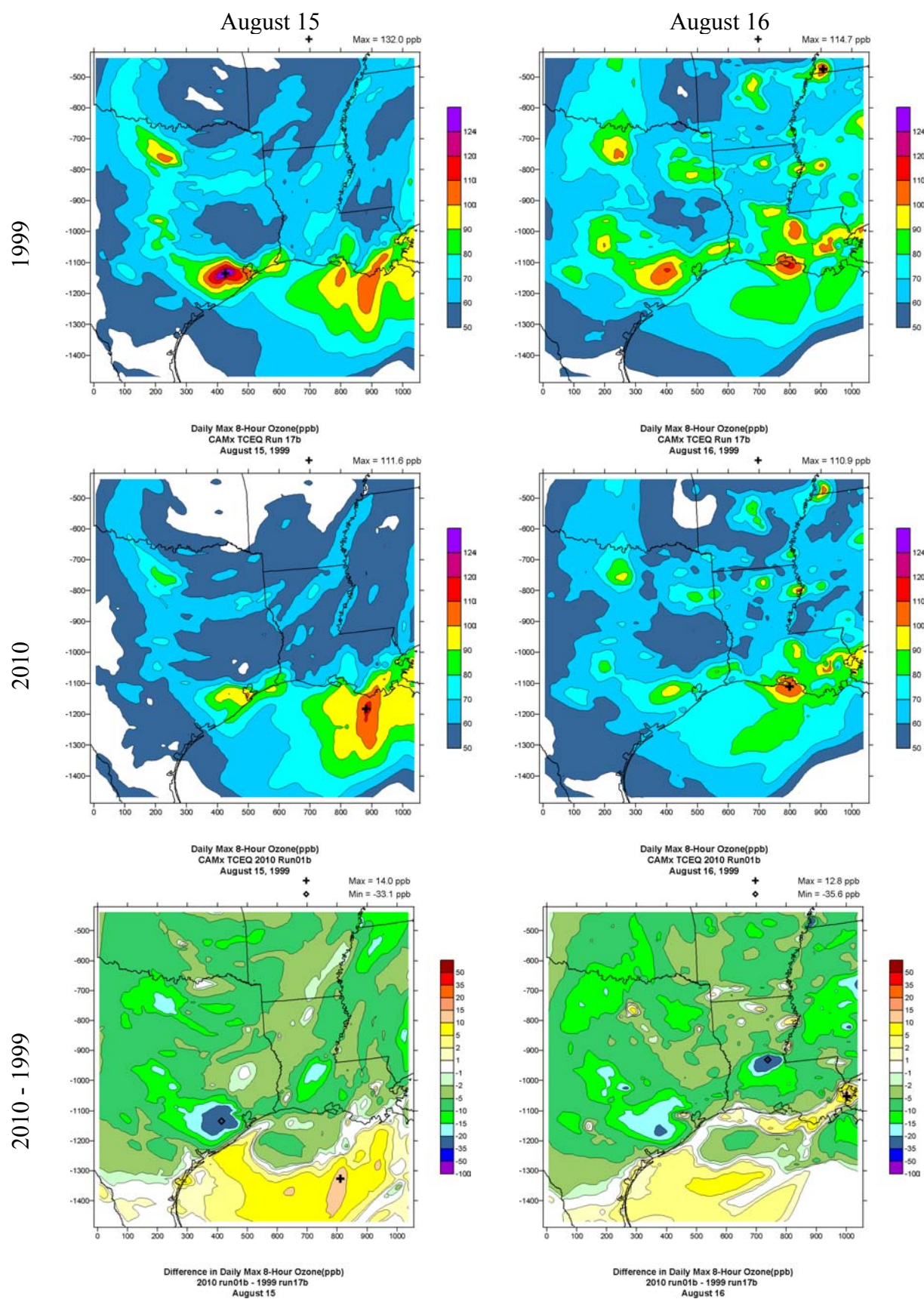


Figure 3-4. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

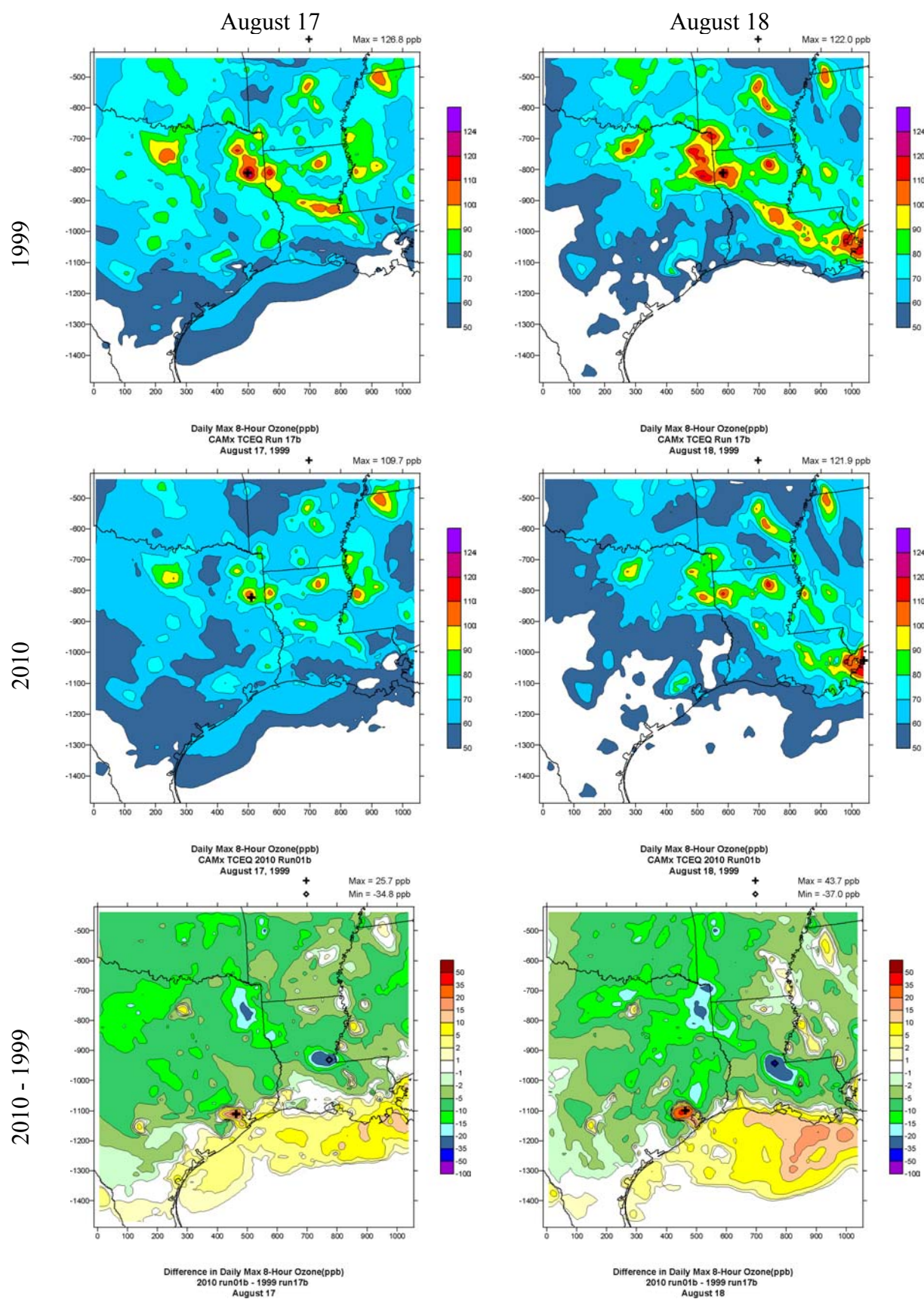


Figure 3-4. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

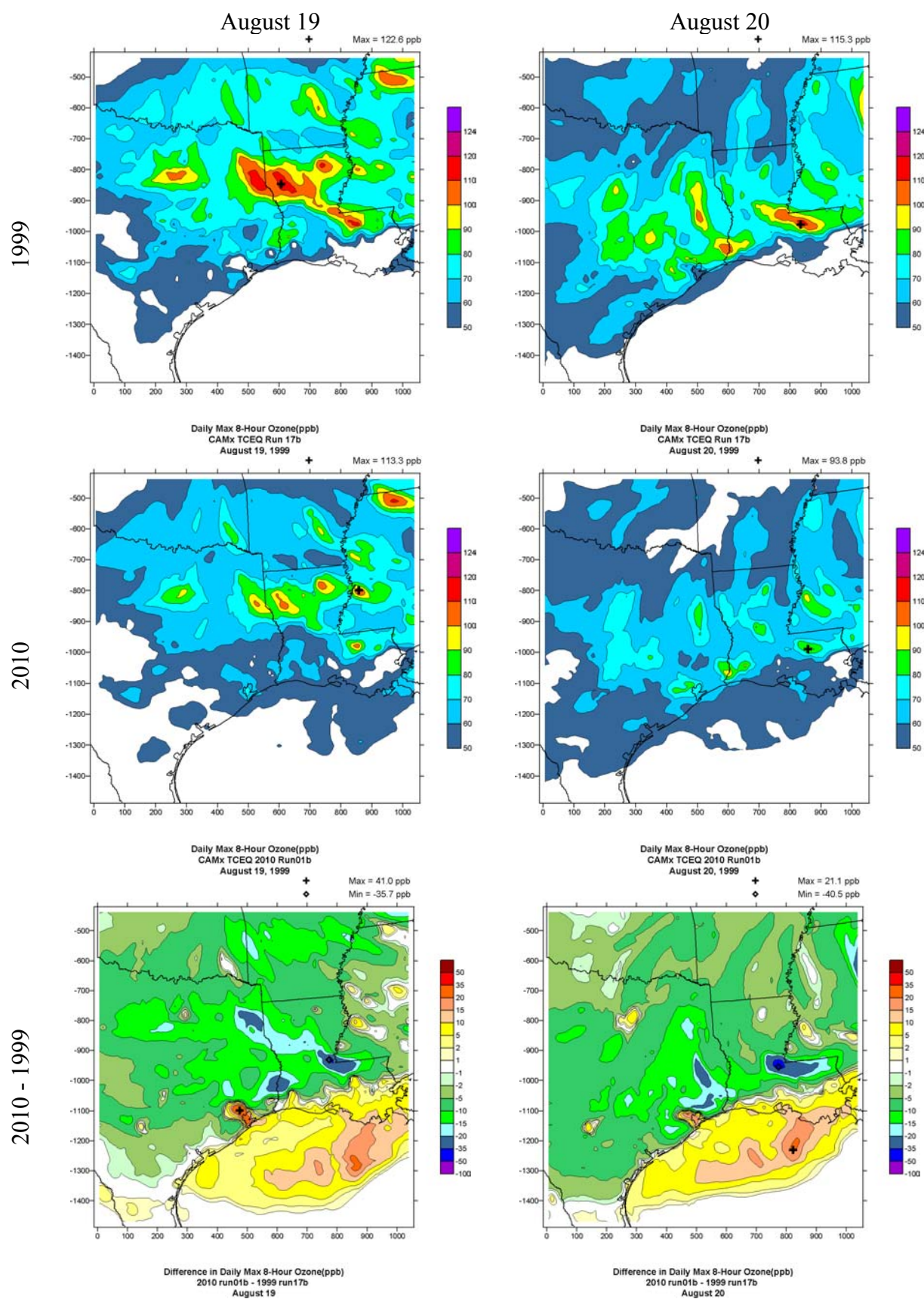


Figure 3-4. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

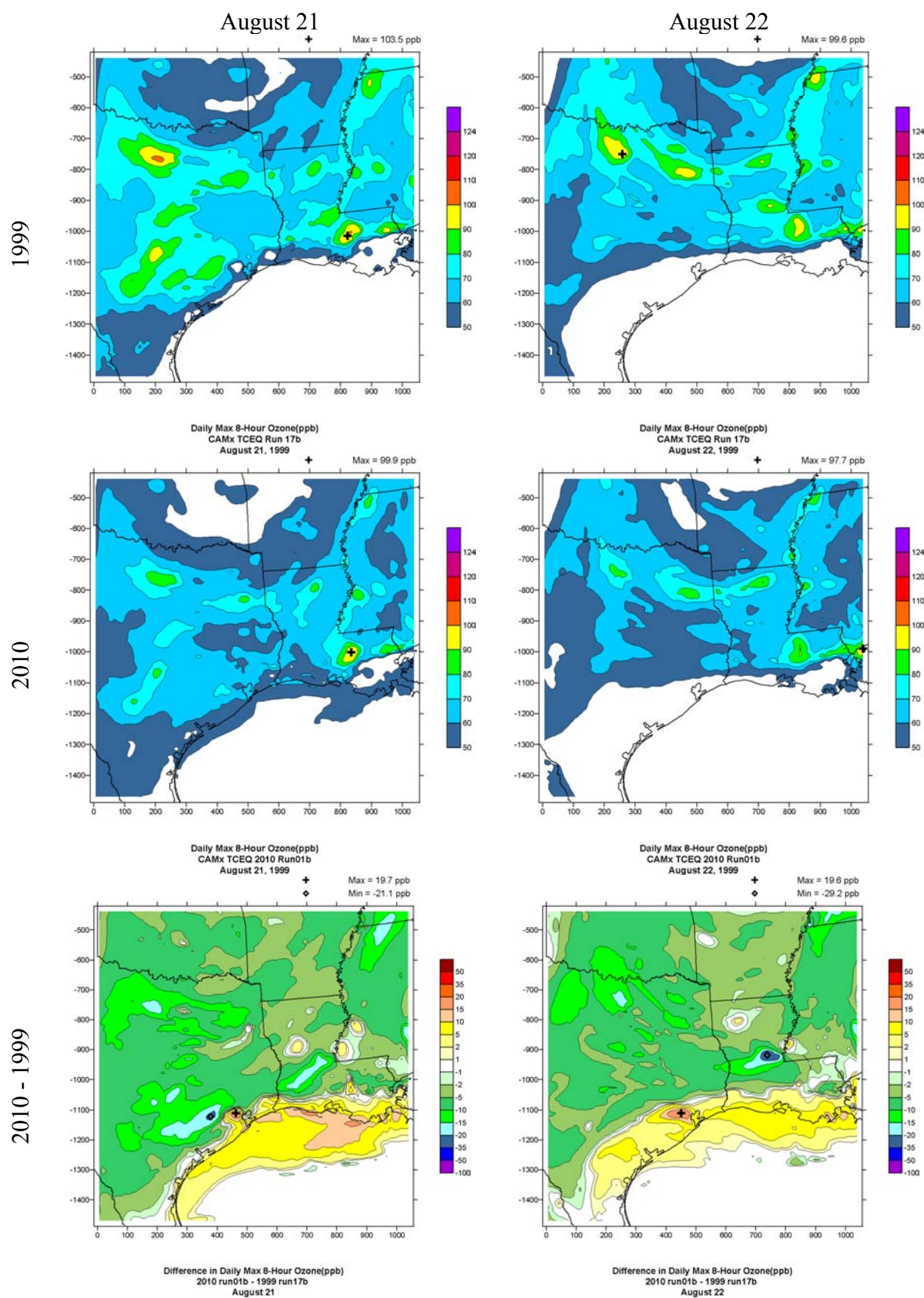


Figure 3-4. Daily maximum 8-hour ozone (ppb) in 2010 and 1999 and difference (2010-1999).

PROJECTED 2010 8-HOUR OZONE DESIGN VALUES

Design Value Scaling Methodology for 8-Hour Ozone

The methodology for the 8-hour ozone attainment test was described in draft modeling guidance issued by EPA (EPA, 1999). The methodology calls for scaling base year design values (DVs) using relative reduction factors (RRFs) from a photochemical model in order to estimate future design values using the following equations:

$$\text{Future Year DV} = \text{Base Year DV} \times \text{RRF}$$

$$\text{RRF} = \text{Future Year Modeled Ozone} / \text{Base Year Modeled Ozone}$$

This methodology is conceptually simple, but the implementation is complicated and is described in detail below. This methodology was implemented in a computer program to automate the calculation for efficiency and reliability.

Calculating RRFs

RRFs are calculated for each monitor location. In addition, since high ozone can also occur away from monitor locations, a screening calculation is also carried out to identify grid cells with consistently high ozone. If any screening cells are identified, RRFs are then calculated for the screened grid cells. The idea behind the screening cells is to account for any areas with consistently high modeled ozone that are not captured by the monitoring network. Since there is no base year DV for a screening cell, the DV from a nearby representative monitor must be used. The attainment test is passed when all the future year scaled DVs are 84 ppb or less.

Figure 3-5 shows a schematic outline of the calculations and identifies the input data required to complete the calculation. These are:

1. A monitor list – the list of monitors along with base year DVs for each monitor.
2. A screening cell list – the list of cells to be considered in the screening cell calculation along with the monitors that are considered to be associated with that grid cell. This list may be a subset of the modeling grid covering just the area for which controls are being developed. The significance of associating monitors with each grid cell is in the selection of an appropriate base year DV for the grid cell and in setting concentration thresholds for including the grid cell in the screening calculation, discussed below. There are no firm criteria for deciding how to associate monitors with grid cells.
3. Base case ozone – gridded 8-hour daily maximum ozone for the base year.
4. Future case ozone – gridded 8-hour daily maximum ozone for the future year.

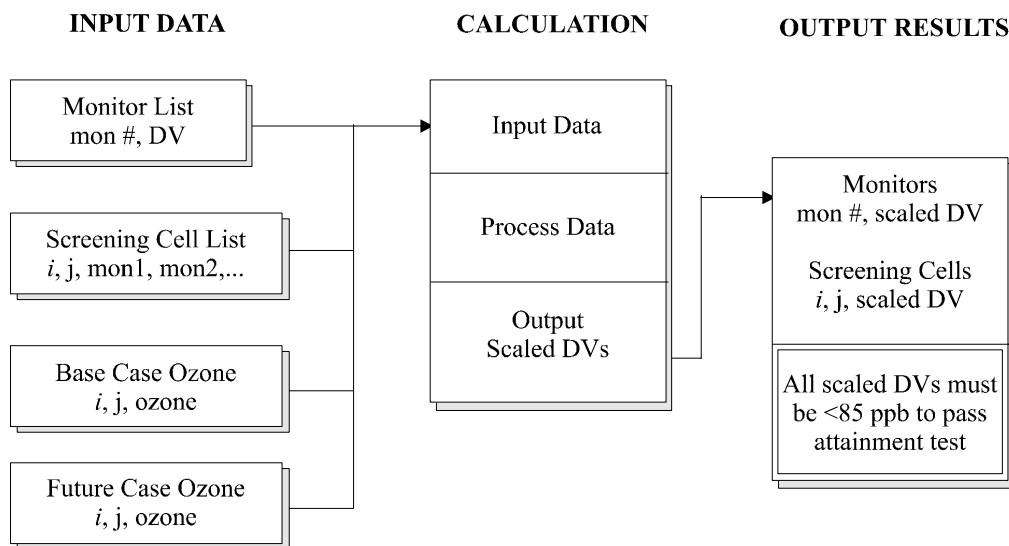


Figure 3-5. Overview of the 8-hour ozone attainment test methodology.

The details of the calculations are as follows:

- Monitor DV Scaling
 1. For each monitor, find the daily maximum 8-hour ozone in an $n \times n$ block of cells around the monitor for both the base and future case. Repeat for each modeling day being used for control strategy development. For a 4 km grid, $n=7$ or 9 are consistent with the guidance.
 2. Exclude days when the base case daily maximum 8-hour ozone was below 70 ppb.
 3. Average the daily maximum 8-hour ozone across days for the base and future year.
 4. Calculate the RRF = (average future daily max) / (average base daily max).
 5. Calculate the scaled DV = base year DV x RRF and truncate to nearest ppb.
 6. Repeat 1-5 for each monitor
- Screening Cell DV Scaling
 7. For each grid cell on the screening cell list, count the number of days where the modeled daily maximum 8-hour ozone is at least 5% greater than the modeled daily maximum 8-hour ozone at any “associated” monitor, and at least 70 ppb.
 8. If the number of days is 50% or greater of the total days, treat this cell as if it were a monitor – this is a “screened cell.”
 9. The base year DV to be used for a screened cell is the maximum of the base year DVs for any “associated” monitor.
 10. Calculated the scaled DV for each screened cell as if it were a monitor (steps 1-5 above).
 11. Repeat 7-10 for each grid cell on the screening cell list.

We make two deviations from EPA’s draft guidance (EPA, 1999). First, in Step 4 the draft guidance says to round the average base and future daily maximum 8-hour ozone concentrations to the nearest ppb before calculating the RRFs, whereas we use the full precision of the modeled values. Rounding the average daily maximum 8-hour ozone concentrations in Step 4 doesn’t make sense at this point in the calculations as it loses precision and will result in “step-function” RRFs

that are illogical. The second deviation from EPA's draft guidance is that they recommend rounding the RRFs to 2 digits to the right of the decimal point, whereas again we use full precision. Again we believe this is an unnecessary loss of precision, however in this case it has little effect.

Dallas/Ft. Worth 8-Hour Design Values

The current 8-hour design values for the Dallas/Ft. Worth non-attainment area are presented in Table 3-1. The 8-hour design value for an individual monitor is defined as the fourth highest monitored 8-hour ozone value averaged over the most recent three years of data. EPA will use the 2000-2003 design values for 8-hour ozone attainment designations. However, because the modeling episode is for 1999, the EA modeling guidance (EPA, 1999) says that the design value scaling must consider the highest design value at each monitor over the period from 1998 to 2003.

The data presented in Table 3-1 includes all monitors with a 1998-2000 or 2000-2003 design value. Also presented in Table 3-1 is the highest 3-year design values based on 1998 to 2003 data. Figure 3-6 displays the location of ozone monitors within the DFW nonattainment area. The specific period for which the maximum design occurs is also denoted in Figure 3-6.

Table 3-1. DFW 8-Hour O₃ Design Values.

County	City	CAMS	1998-2000	1999-2001	2000-2002	2001-2003	Max DV	Ending Year of Max DV
Collin	Frisco	C31	101	99	93	88	101	2000
Collin	Anna	C68			83	80	83	2002
Dallas	Dallas	C60,C401	93	92	91	90	93	2000
Dallas	Dallas	C63		93	89	86	93	2001
Dallas	Dallas	C402	88	82	82	83	88	2000
Dallas	Sunnyvale	C74				83	83	2003
Denton	Denton	C56	102	101	99	97	102	2000
Ellis	Midlothian	C94	97	88	86	82	97	2000
Hood	Granbury	C73			84	84	84	2002
Johnson	Cleburne	C77			89	90	90	2003
Kaufman	Kaufman	C71			70	73	73	2003
Parker	Weatherford	C76			86	89	89	2003
Rockwall	Rockwall	C69			83	81	83	2002
Tarrant	Arlington	C57	95	86			95	2000
Tarrant	Eagle Mountain Lake	C75			95	96	96	2003
Tarrant	Fort Worth	C13	99	97	96	96	99	2000
Tarrant	Fort Worth	C17	97	97	98	100	100	2003
Tarrant	Grapevine	C70			95	100	100	2003

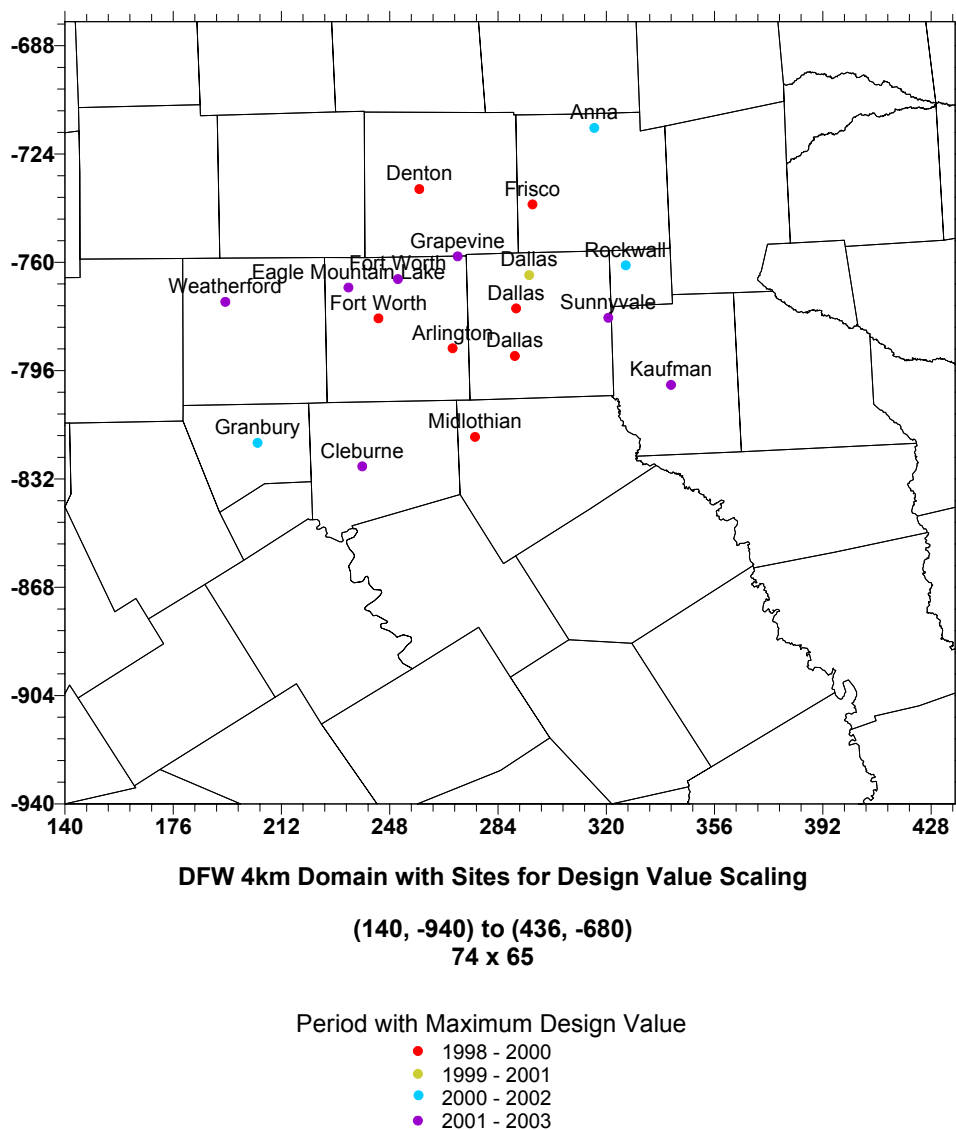


Figure 3-6. DFW ozone monitors and maximum design value periods.

The results of the design value scaling analysis are presented in Table 3-2. Yellow shaded values in the right hand column of the lower panel indicate monitors that fail the attainment test (8-hour $O_3 < 85.0$) for 2007. Several monitors are seen to fail the attainment test although the scaled 8-hour ozone values at four monitors (Dallas C402, Cleburne, Weatherford and Eagle Mt Lake) have been reduced to below 85 ppb.

Table 3-2. 2010 8-hour ozone design value scaling analysis for monitors in the DFW area. The scaled 2010 design values are in the right hand column of the lower panel.

Base Case: run17b			Base Case Max 8-Hr Ozone (ppb)											#Days above 70 ppb
Site	MaxDV	DVyear	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	Avg	
Frisco	101	2000	56.9	64.8	77.5	88.8	88.0	113.3	82.5	65.7	80.8	89.5	88.6	7
Anna	83	2002	58.6	65.9	69.6	70.0	79.2	103.9	86.7	66.2	73.1	82.4	82.6	6
Dallas C60	93	2000	55.3	76.2	91.2	88.6	89.8	86.3	91.8	63.6	87.2	84.1	86.9	8
Dallas C63	93	2001	54.7	70.0	86.4	83.7	84.9	91.7	86.7	62.7	82.0	87.3	84.1	8
Dallas C402	88	2000	56.9	80.4	91.2	88.6	89.8	80.9	102.8	70.9	87.2	77.2	85.4	9
Sunnyvale	83	2003	63.4	64.0	67.4	69.0	77.2	82.9	87.0	65.1	72.6	73.2	78.6	5
Denton	102	2000	62.5	68.1	94.6	103.0	107.2	116.5	86.3	67.0	92.9	100.9	100.2	7
Midlothian	97	2000	55.1	73.7	72.3	73.1	83.2	74.5	107.4	75.4	76.3	73.6	78.8	9
Granbury	84	2002	53.7	87.9	85.7	72.7	79.4	72.0	98.8	72.7	82.8	74.3	80.7	9
Cleburne	90	2003	55.7	81.1	80.2	75.8	80.9	67.6	102.7	86.2	81.7	74.1	82.8	8
Kaufman	73	2003	62.0	67.2	69.2	65.8	74.4	74.8	91.2	66.4	76.1	70.6	77.4	5
Weatherford	89	2003	58.5	101.8	100.4	89.9	98.5	73.4	81.7	65.6	103.0	80.5	91.2	8
Rockwall	83	2002	62.8	64.0	69.0	68.6	77.2	84.6	87.0	64.3	76.2	74.0	79.8	5
Arlington	95	2000	57.1	91.0	97.8	90.6	96.2	82.2	100.7	67.6	92.9	82.2	91.7	8
Eagle Mt Lake	96	2003	62.2	98.5	107.2	102.8	106.7	96.1	86.0	65.8	101.6	93.4	99.0	8
Fort Worth C13	99	2000	62.2	97.2	106.4	100.5	106.2	92.5	89.6	71.2	100.6	91.1	95.0	9
Fort Worth C17	100	2003	64.3	90.0	104.3	102.7	108.0	102.0	88.9	71.2	97.8	99.9	96.1	9
Grapevine	100	2003	64.3	80.3	101.7	103.0	107.0	113.4	88.9	71.2	94.6	100.9	95.7	9

Future Year: 10run01b			Future Case Max 8-Hr Ozone (ppb)												
Site	Max DV	DV year	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	Avg	RRF	2007 DV
Frisco	101	2000	54.9	60.6	66.9	88.6	86.5	106.3	72.0	58.8	71.2	76.2	81.1	0.9150	92.4
Anna	83	2002	54.5	55.4	60.1	62.1	71.6	91.1	75.1	60.6	62.9	69.4	72.0	0.8726	72.4
Dallas C60	93	2000	61.9	74.9	77.9	88.1	90.3	85.3	89.3	67.3	80.1	77.1	82.9	0.9535	88.7
Dallas C63	93	2001	61.7	69.2	74.6	86.5	85.4	94.8	81.7	63.5	77.7	76.0	80.7	0.9601	89.3
Dallas C402	88	2000	61.9	74.9	76.4	84.5	86.8	80.0	96.1	72.2	80.1	67.7	79.9	0.9345	82.2
Sunnyvale	83	2003	66.5	57.4	60.3	65.3	71.9	77.8	82.5	61.2	67.0	66.2	73.1	0.9301	77.2
Denton	102	2000	55.3	58.3	78.4	93.0	97.6	103.9	70.8	59.0	77.7	83.5	86.4	0.8623	88.0
Midlothian	97	2000	52.6	65.8	66.0	68.8	77.0	67.0	96.7	75.5	66.3	66.2	72.1	0.9150	88.8
Granbury	84	2002	48.6	78.3	75.6	66.1	69.9	65.9	81.4	65.7	76.2	65.2	71.6	0.8872	74.5
Cleburne	90	2003	50.9	74.2	72.1	68.9	71.7	59.8	87.4	79.2	72.5	64.2	73.8	0.8907	80.2
Kaufman	73	2003	58.1	56.5	57.9	59.8	69.2	65.2	79.6	58.9	65.9	63.6	68.7	0.8869	64.7
Weatherford	89	2003	52.9	85.7	83.3	78.1	84.0	60.6	69.0	59.4	85.5	69.1	76.9	0.8436	75.1
Rockwall	83	2002	66.5	56.7	59.2	64.5	71.9	78.2	75.8	58.7	64.3	66.2	71.3	0.8935	74.2
Arlington	95	2000	59.2	86.1	79.9	85.4	88.8	80.0	92.7	70.7	82.0	73.6	83.6	0.9114	86.6
Eagle Mt Lake	96	2003	59.4	88.2	89.0	92.1	97.0	82.1	74.6	62.0	89.9	79.1	86.5	0.8733	83.8
Fort Worth C13	99	2000	59.4	92.9	87.0	94.7	99.0	84.2	81.7	66.7	88.6	78.9	86.0	0.9046	89.6
Fort Worth C17	100	2003	57.9	83.9	85.0	97.1	103.7	89.6	76.1	62.9	88.6	85.6	85.8	0.8933	89.3
Grapevine	100	2003	57.1	74.5	84.8	97.1	103.7	108.7	73.4	61.8	87.9	85.6	86.4	0.9029	90.3

EMISSION SENSITIVITY SIMULATIONS FOR 2010

In order to support the development of a State Implementation Plan for the Dallas/Fort Worth area and to provide some guidance with respect to emission reductions necessary to bring the DFW area in to attainment of the 8-hour ozone standard, a series of emission reductions scenarios based on the 2010 future year photochemical modeling results. Specifically, NO_x and VOC anthropogenic emissions reductions, both separately and in combination, were applied to the 9-county DFW area to provide directional guidance in the development of control measures. These scenarios were designed to determine the level of emissions reductions required affect the necessary reductions in predicted daily maximum 8-hour ozone concentrations. In addition, these simulations seek to address whether NO_x and/or VOC emission controls are more effective. Table 3-3 summarizes the emission reduction scenarios considered.

Table 3-3. Emission reduction matrix for 'Directional Guidance' sensitivity simulations.

Anthropogenic Reductions		NO _x			
		0%	20%	40%	60%
	0%	Future Base	X	X	X
	25%	X	X	-	-
VOC	50%	X		X	-
	75%	X	-		X

In addition to across-the-board anthropogenic emission reductions, a number of emission reduction scenarios were considered wherein a specified total tonnage of NO_x and VOC emissions were reduced for specific emission source categories. A nominal value of 40 tons per day (tpd) was selected for these simulations. As the emissions inventory varies from day to day, in order to realize a 40 tpd reduction for each episode day, the corresponding percentage reduction across the 9-county DFW region was calculated for each episode day for each source category considered. The daily emissions for each of the nine DFW counties and the corresponding percentage required to achieve a 40 tpd reduction in emissions are presented in Table 3-4.

In the development of these emission scenarios, note that no reduction of point source VOC emissions were considered because, typically, stationary point sources are only a minor source of VOC emissions. Note also, that in order to avoid completely removing emission components from individual counties, the calculations are based on the 9-county totals. The percentage reductions are then applied uniformly across the entire region. In this way, the analysis does not favor any particular county over the others in the region. Finally, prior to initiating the air quality simulations, the percent reductions were reviewed for reasonableness. For example, it would not be reasonable to expect emission reductions greater than approximately 75% for any source category. Examination of Table 3-4 shows emission reductions ranging from approximately 13% to 75%, depending on the episode day, pollutant and emission source category.

Table 3-4. Source-specific emission reductions percentages based on 40 tpd reduction across the DFW 9-County region.

	Aug 13 (Friday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	11.7	7.7	3.0	1.2	14.9	19.0
Dallas	62.3	38.3	18.0	12.2	67.8	111.7
Denton	13.9	8.2	2.7	1.7	17.9	23.2
Tarrant	41.6	25.1	13.0	9.7	54.4	85.8
Parker	5.7	2.4	4.1	1.0	5.1	13.0
Johnson	5.3	2.9	4.4	0.2	7.7	15.5
Ellis	8.2	2.7	44.5	6.9	9.0	15.0
Kaufman	5.8	2.8	6.8	2.0	3.2	14.1
Rockwall	2.3	0.8	0.0	0.0	1.0	3.7
9 County Total	156.8	90.9	96.5	34.9	181.0	300.9
%reduction	26%	44%	41%	N/A	22%	13%
	Aug 14 (Saturday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	8.0	5.4	2.2	0.6	10.7	16.4
Dallas	40.7	26.9	17.4	9.3	50.6	79.0
Denton	9.3	5.8	2.6	1.1	15.8	21.3
Tarrant	28.4	17.8	12.3	7.1	43.8	55.0
Parker	3.8	2.0	4.2	1.0	4.8	11.6
Johnson	3.6	2.4	4.3	0.2	7.2	11.5
Ellis	5.1	2.3	44.5	6.8	6.6	13.2
Kaufman	3.8	2.4	6.8	2.0	2.8	7.9
Rockwall	1.3	0.6	0.0	0.0	0.7	3.3
9 County Total	104.0	65.7	94.3	28.1	142.9	219.2
%reduction	38%	61%	42%	N/A	28%	18%

	Aug 15 (Sunday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	6.1	4.3	2.7	0.6	8.3	13.0
Dallas	31.2	21.4	16.9	9.3	38.0	62.2
Denton	6.9	4.6	2.5	1.1	14.4	18.6
Tarrant	20.7	14.1	12.9	7.2	36.1	43.8
Parker	3.4	2.0	4.3	1.0	4.6	9.5
Johnson	3.5	2.4	4.3	0.2	6.8	8.6
Ellis	4.8	2.4	44.5	6.8	5.4	10.2
Kaufman	3.8	2.4	6.8	2.0	2.6	5.6
Rockwall	1.0	0.5	0.0	0.0	0.5	2.6
9 County Total	81.3	54.2	95.0	28.2	116.7	174.1
%reduction	49%	74%	42%	N/A	34%	23%
	Aug 16 (Monday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	11.9	7.0	3.0	1.2	14.9	19.0
Dallas	62.9	34.3	18.0	12.2	67.8	111.7
Denton	14.1	7.5	2.7	1.7	17.9	23.2
Tarrant	42.0	22.8	13.0	9.7	54.4	85.8
Parker	4.9	1.8	4.1	1.0	5.1	13.0
Johnson	4.5	2.2	4.4	0.2	7.7	15.5
Ellis	6.8	2.1	44.5	6.9	9.0	15.0
Kaufman	5.0	2.1	6.8	2.0	3.2	14.1
Rockwall	2.3	0.7	0.0	0.0	1.0	3.7
9 County Total	154.5	80.4	96.5	34.9	181.0	300.9
%reduction	26%	50%	41%	N/A	22%	13%

	Aug 17 (Tuesday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	11.9	7.2	3.0	1.2	14.9	19.0
Dallas	62.4	35.2	18.0	12.2	67.8	111.7
Denton	14.3	7.7	2.7	1.7	17.9	23.2
Tarrant	42.2	23.2	13.0	9.7	54.4	85.8
Parker	5.0	1.9	4.1	1.0	5.1	13.0
Johnson	4.4	2.2	4.4	0.2	7.7	15.5
Ellis	6.8	2.1	44.5	6.9	9.0	15.0
Kaufman	4.9	2.1	6.8	2.0	3.2	14.1
Rockwall	2.3	0.8	0.0	0.0	1.0	3.7
9 County Total	154.4	82.3	96.5	34.9	181.0	300.9
%reduction	26%	49%	41%	N/A	22%	13%
	Aug 18 (Wednesday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	11.4	7.2	3.0	1.2	14.9	19.0
Dallas	60.2	35.4	18.0	12.2	67.8	111.7
Denton	13.6	7.7	2.7	1.7	17.9	23.2
Tarrant	40.0	23.3	13.0	9.7	54.4	85.8
Parker	4.8	1.9	4.1	1.0	5.1	13.0
Johnson	4.2	2.2	4.4	0.2	7.7	15.5
Ellis	6.7	2.1	44.5	6.9	9.0	15.0
Kaufman	4.7	2.1	6.8	2.0	3.2	14.1
Rockwall	2.2	0.8	0.0	0.0	1.0	3.7
9 County Total	147.8	82.7	96.5	34.9	181.0	300.9
%reduction	27%	48%	41%	N/A	22%	13%

	Aug 19 (Thursday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	11.8	7.3	3.0	1.2	14.9	19.0
Dallas	60.9	35.6	18.0	12.2	67.8	111.7
Denton	13.6	7.8	2.7	1.7	17.9	23.2
Tarrant	40.0	23.4	13.0	9.7	54.4	85.8
Parker	4.7	1.9	4.1	1.0	5.1	13.0
Johnson	4.2	2.3	4.4	0.2	7.7	15.5
Ellis	6.7	2.1	44.5	6.9	9.0	15.0
Kaufman	4.7	2.1	6.8	2.0	3.2	14.1
Rockwall	2.2	0.8	0.0	0.0	1.0	3.7
9 County Total	148.9	83.2	96.5	34.9	181.0	300.9
%reduction	27%	48%	41%	N/A	22%	13%
	Aug 20 (Friday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	13.6	7.8	3.0	1.2	14.9	19.0
Dallas	69.1	38.0	18.0	12.2	67.8	111.7
Denton	16.0	8.3	2.7	1.7	17.9	23.2
Tarrant	47.8	25.2	13.0	9.7	54.4	85.8
Parker	6.7	2.4	4.1	1.0	5.1	13.0
Johnson	6.1	2.8	4.4	0.2	7.7	15.5
Ellis	8.8	2.7	44.5	6.9	9.0	15.0
Kaufman	6.6	2.7	6.8	2.0	3.2	14.1
Rockwall	2.6	0.8	0.0	0.0	1.0	3.7
9 County Total	177.2	90.8	96.5	34.9	181.0	300.9
%reduction	23%	44%	41%	N/A	22%	13%

	Aug 21 (Saturday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	8.2	5.4	2.2	0.6	10.7	16.4
Dallas	42.3	26.3	17.4	9.3	50.6	79.0
Denton	9.4	5.8	2.6	1.1	15.8	21.3
Tarrant	28.3	17.4	12.3	7.1	43.8	55.0
Parker	3.9	2.0	4.2	1.0	4.8	11.6
Johnson	3.8	2.4	4.3	0.2	7.2	11.5
Ellis	5.2	2.3	44.5	6.8	6.6	13.2
Kaufman	4.0	2.3	6.8	2.0	2.8	7.9
Rockwall	1.3	0.6	0.0	0.0	0.7	3.3
9 County Total	106.5	64.4	94.3	28.1	142.9	219.2
%reduction	38%	62%	42%	N/A	28%	18%
	Aug 22 (Sunday)					
	On-Road Mobile		Points		Area+Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC
County						
Collin	5.8	4.4	2.7	0.6	8.3	13.0
Dallas	31.1	21.5	16.9	9.3	38.0	62.2
Denton	6.8	4.7	2.5	1.1	14.4	18.6
Tarrant	20.5	14.2	12.9	7.2	36.1	43.8
Parker	3.4	2.0	4.3	1.0	4.6	9.5
Johnson	3.5	2.4	4.3	0.2	6.8	8.6
Ellis	4.7	2.4	44.5	6.8	5.4	10.2
Kaufman	3.6	2.4	6.8	2.0	2.6	5.6
Rockwall	0.9	0.5	0.0	0.0	0.5	2.6
9 County Total	80.3	54.4	95.0	28.2	116.7	174.1
%reduction	50%	73%	42%	N/A	34%	23%

Each of the emission reduction scenarios described above were simulated in CAMx. For each simulation, the episode peak predicted 8-hour ozone in the DFW 4-km modeling domain was calculated. In addition, 8-hour ozone values for each monitor in the region were evaluated. The results of these emission sensitivity simulations are presented graphically in Figures 3-7 through 3-9. The 40 ton per day scenarios were included here in terms of the associated percentage reductions corresponding to each. In each figure, the predicted 8-hr peak ozone value within the DFW 4-km modeling domain is shown as the top curve. Note the monitor values illustrated in the figures are scaled design values, calculated according to EPA's methodology. In order to demonstrate

attainment, all these scaled design values must be below 85 ppb, although a weight of evidence argument can be used in cases where these future year design values are below 90 ppb.

Based on these results, the following observations can be made:

- NO_x controls are more effective VOC controls, although VOC emission reductions do contribute slightly to reducing the 8-hour ozone concentrations.
- Nearly 50% to 60% NO_x reductions are necessary to bring the highest ozone monitors into attainment (below 85 ppb).
- A 60% NO_x reduction is needed for the four highest monitors (Frisco, Midlothian, Dallas C60 and Dallas C63) to reduce 8-hour ozone levels to below 85 ppb.
- There is no evidence of a NO_x disbenefit in the design values scaling
- Some monitors exhibit non-responsive behavior (i.e., Midlothian)
- The non-responsive behavior of the Dallas C60 and C63 monitors may be due to their proximity to the areas of disbenefits seen in Figure 3-3.
- These sensitivity simulations are for area-wide emissions reductions – source-specific reductions might be more or less effective at the monitor locations.

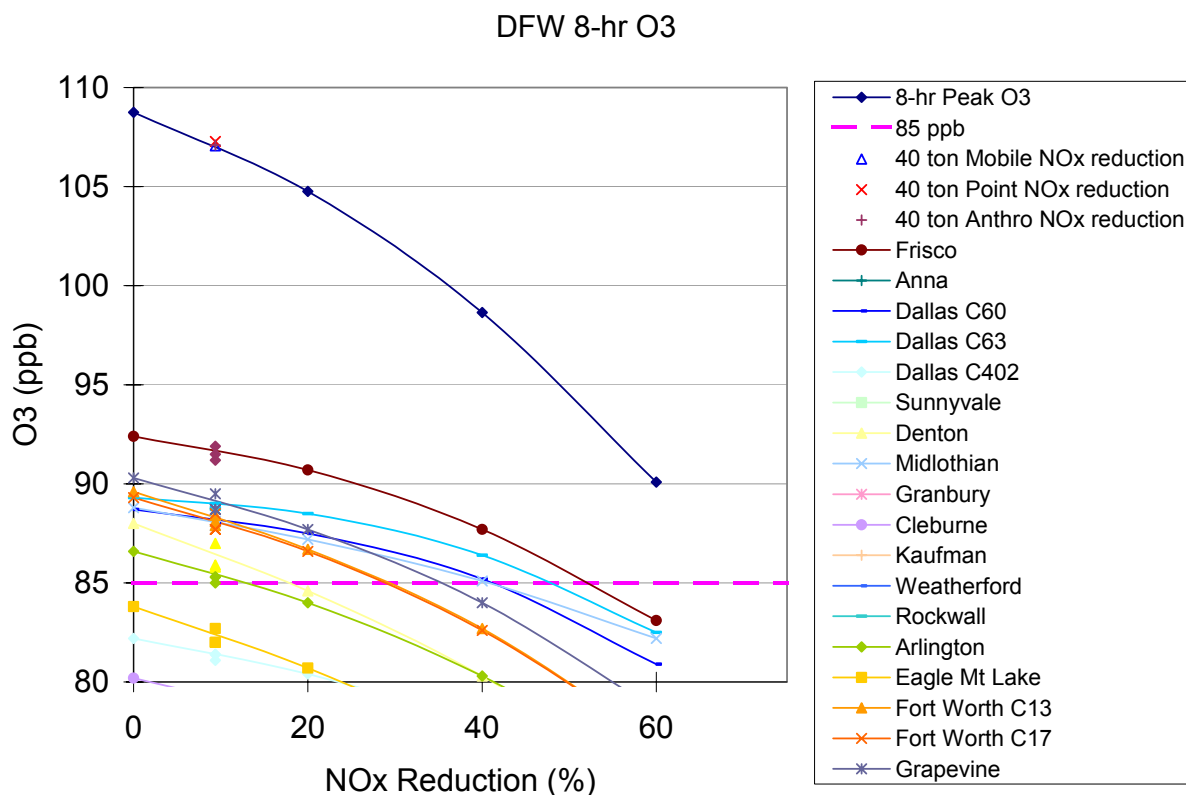


Figure 3-7. Eight-hour ozone response curves for NO_x emission reduction scenarios.

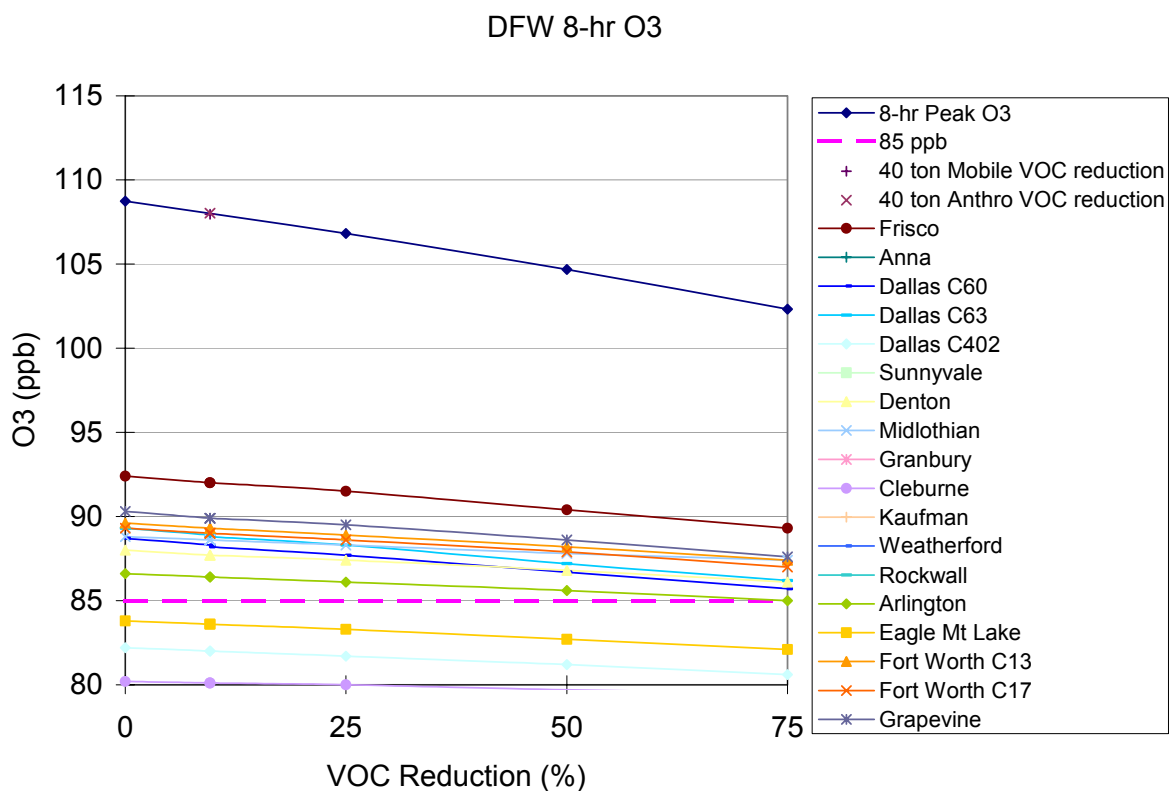


Figure 3-8. Eight-hour ozone response curves for VOC emission reduction scenarios.

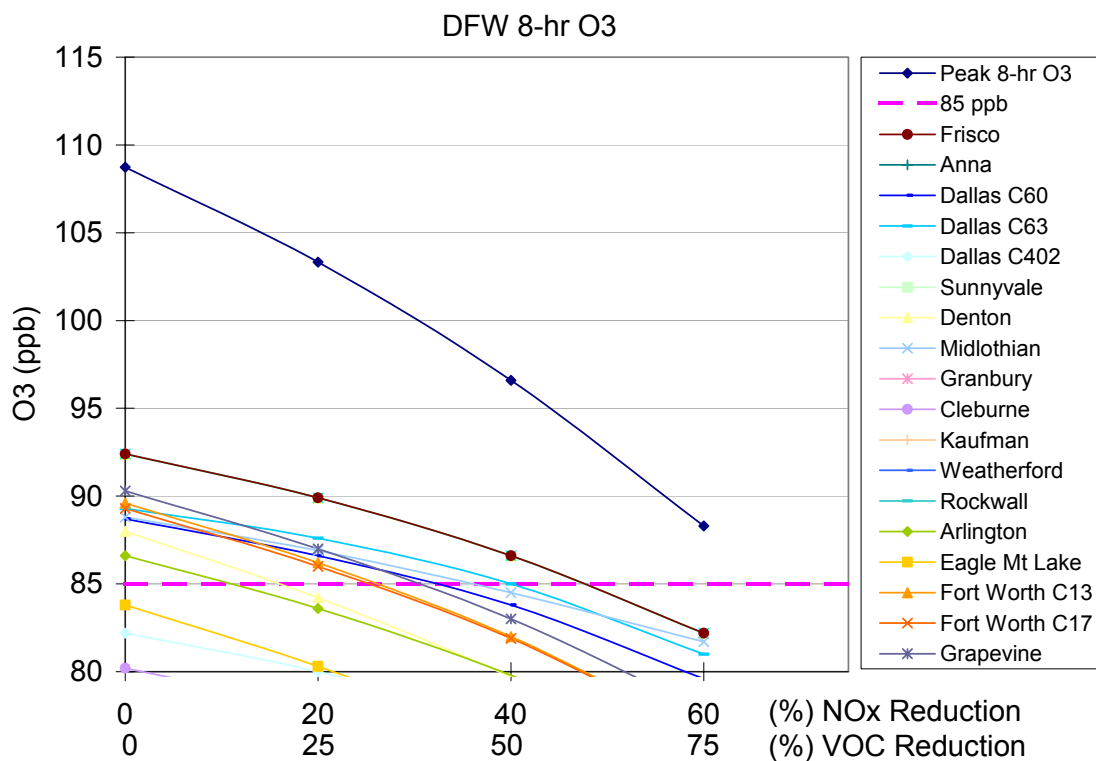


Figure 3-9. Eight-hour ozone response curves for NO_x/VOC emission reduction scenarios.

4.0 SUMMARY AND CONCLUSIONS

The CAMx air quality model was applied for the August 13 –22, 1999 Dallas/Ft. Worth ozone episode. Version 4.03 of the CAMx air quality model was run for the 1999 base year and the 2007 future year. The development of the input databases for 1999 was documented in Mansell et al., 2003 and Emery et al., 2004. Emission inventories for the 2010 future year were developed jointly by ENVIRON and TCEQ as described above. Modeling results and performance evaluation of the 1999 base case was presented in Emery et al., 2004. The main points from the ozone modeling results 2010 are summarized below.

1-Hour Ozone for 2010

The spatial distributions of 1-hour ozone concentrations are shown in Figure 3-1.

- Peak 1-hour ozone levels exceeded the level of the 1-hour ozone standard (124 ppb) on only one day of the episode days, August 17th.
- The 1-hour ozone peak on August 17th was 125.5 ppb for 2010 compared to 135.7 ppb for 1999. This peak value occurred downwind of DFW to the west and was not very responsive to the emissions reductions in the DFW area from 1999 to 2010. The observed peak ozone on 17 August 1999 was 150 ppb to the north of Dallas.
 - August 17th is the day with the poorest model performance due to a bias in the MM5 wind field (Mansell et al., 2003). The normalized bias for 17 August 1999 was –27%, which is outside the EPA goal of +/- 15%.
 - Because the modeled and observed peaks are in different locations, it is difficult to estimate whether a “relative reduction factor” analysis would find that 1-hour ozone levels are more responsive to emission reductions than the peak ozone.
- The spatial distribution of elevated ozone levels between the 1999 and 2010 base case simulations are similar.
- Broad regions of reductions in 1-hour ozone concentrations are seen throughout the region although there is a fairly large area of ozone disbenefits in the Dallas urban core.

8-Hour Ozone for 2010

Design values for 8-hour ozone in 2010 are shown in Table 3-1.

- An analysis was completed for 8-hour ozone levels in 2010 using EPA’s design value (DV) scaling methodology.
- The projected 8-hour design values for 2010 exceeded the target level of 84 ppb (after truncation) at 9 of 18 sites considered in the DFW area.

- The relative reduction factor analysis projected that only four monitors (Dallas CAMS402, Cleburne CAMS77, Weatherford CAMS76 and Eagle Mt Lake) would come into attainment of the 8-hour ozone standard by 2010.
- The highest projected 8-hour design values for 2007 was 92.4 ppb at the Frisco monitor.

Emission Reduction Scenarios for 2010

A series of emission reduction scenarios were considered in order to provide “directional guidance” in developing control measure to address the 8-hour ozone standards. Both NO_x and VOC emissions reductions were considered. The reductions were applied to all anthropogenic emissions as well as to specific source categories within the 9-county DFW area. The following observations can be made from these sensitivity simulations:

- NO_x controls are more effective VOC controls, although VOC emission reductions do contribute slightly to reducing the 8-hour ozone concentrations.
- Nearly 50% to 60% NO_x reductions are necessary to bring the highest ozone monitors into attainment (below 85 ppb).
- A 60% NO_x reduction is needed for the four highest monitors (Frisco, Midlothian, Dallas C60 and Dallas C63) to reduce 8-hour ozone levels to below 85 ppb.
- There is no evidence of a NO_x disbenefit in the design values scaling.
- Some monitors exhibit non-responsive behavior (i.e., Midlothian).
- The non-responsive behavior of the Dallas C60 and C63 monitors may be due to their proximity to the areas of disbenefits seen in Figure 3-3.
- The sensitivity simulations are for area-wide emissions reductions – source-specific reductions might be more or less effective at the monitor locations.

5.0 REFERENCES

- Dudhia, J. 1993. "A Non-hydrostatic Version of the Penn State/NCAR Mesoscale Model: Validation Tests and Simulation of an Atlantic Cyclone and Cold Front", *Mon. Wea. Rev.*, Vol. 121. pp. 1493-1513.
- Emery C., Y. Jia, S. Kemball-Cook, G. Mansell, S. Lau, and G. Yarwood. 2004. "Modeling an August 13-22, 1999 Ozone Episode in the Dallas/Fort Worth Area" Prepared for the Texas Commission on Environmental Quality. 31 August 2004.
- ENVIRON. 2004. "2007 Future Year Ozone Modeling for the Dallas/Fort Worth Area." Prepared for the Texas Commission on Environmental Quality by ENVIRON International Corporation, 101 Rowland Way, Novato, CA 94945 and Texas Engineering Experiment Station, 3000 TAMU, College Station, TX 77843. 25 August 2004.
- ENVIRON. 2003a. "Meteorological Modeling. Development of Base Case Photochemical Modeling to Address 1-Hour and 8-Hour Ozone Attainment in the Dallas/Ft Worth Area." Prepared for the Texas Commission on Environmental Quality by ENVIRON International Corporation, 101 Rowland Way, Novato, CA 94945. 30 June 2003.
- ENVIRON. 2003b. "Modeling a 1999 Ozone Episode in Northeast Texas" Prepared for the East Texas Council of Governments by ENVIRON International Corporation, 101 Rowland Way, Novato, CA 94945. 5 May 2003.
- ENVIRON. 2002. "User's Guide to the Comprehensive Air Quality model with extensions, version 3.10" available from www.camx.com. April.
- ENVIRON. 2001. "User's Guide to the extended Emissions Processing Systems version 2 (EPS2x)." ENVIRON International Corporation, 101 Rowland Way, Novato, CA. 94945. August.
- EPA. 1999. "Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS". EPA-454/R-99-004. EPA Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. May.
- Guenther, A., C. Wiedinmyer, B. Baugh, S. Shepard, U. Ganesh, and G. Yarwood. 2002. "Biogenic VOC Emission Estimates for the TexAQS 2000 Emission Inventory: Estimating Emissions During Periods of Drought and Prolonged High Temperatures and Developing GloBEIS3". Prepared for Texas Natural Resource Conservation Commission, Austin, TX. April.
- Mansell G., G. Yarwood, M. Jimenez, T. Dihn. Development of Base Case Photochemical Modeling to Address 1-Hour and 8-Hour Ozone Attainment in the Dallas/Fort Worth Area. Prepared for the TCEQ. October 2003.
- Madronich, S. 2002. The Tropospheric visible Ultra-violet (TUV) model web page. <http://www.acd.ucar.edu/TUV/>.

- Madronich, S. 1993. "UV radiation in the natural and perturbed atmosphere", in *Environmental Effects of UV (Ultraviolet) Radiation* (M. Tevini, ed.), Lewis Publisher, Boca Raton, pp. 17-69.
- NETAC 2004. "Draft Clean Air Action Plan for Northeast Texas." Prepared by the Northeast Texas Air Care Technical Committee for the East Texas Council of Governments, 3800 Stone Rd., Kilgore, Texas. January.
- Yarwood, G. G. Mansell, G. McGauhey, and W. Vizuite. 2001. "Biogenic Emission Inventories For Regional Modeling of 1999 Ozone Episodes In Texas". Final Report to the Texas Natural Resource Conservation Commission, Austin, TX. April.
- Yarwood, G., G. Wilson, S. Shepard, and A. Guenther. 1999a. User's Guide to the Global Biosphere Emissions and Interactions System - Version 2.0. Available from <http://www.globeis.com>.
- Yarwood, G., G. Wilson, C. Emery, and A. Guenther. 1999b. "Development of GLOBEIS - A State of the Science Biogenic Emissions Modeling System". Final Report to the Texas Natural Resource Conservation Commission, Austin, TX. Available from <http://www.globeis.com>.